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RESEARCH PAPER

Healthy Foods North improves diet among Inuit and Inuvialuit women of childbearing age in Arctic Canada

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Abstract

Background: Healthy Foods North (HFN) is a community-based intervention designed to promote a healthy diet and lifestyle of Inuit and Inuvialuit populations in Arctic Canada. The objective of the present study was to determine the effects of HFN on the nutrient intake of women of childbearing age.
Methods: Six communities in Nunavut (n = 3) and the Northwest Territories (n = 3) were selected for programme implementation; four received a 12-month intervention and two served as controls. Quantitative food frequency questionnaires were used to assess dietary intake at baseline and 1 year post-intervention. Among women participants aged 19–44 years (n = 136), 79 were exposed to the intervention and 57 were not. Mean daily energy and nutrient intake and density were determined. Dietary adequacy was assessed by comparing the women's daily nutrient intakes with dietary reference intakes (DRI).
Results: Main outcomes were the pre- to post-intervention changes between intervention and control groups for energy and selected nutrient intakes, nutrient density and dietary adequacy. Among the participants, the intervention had a beneficial effect on vitamin A and D intake. The percentage of individuals with nutrient intakes below the DRI increased from pre- to post-intervention for vitamin A and D in the control group but only for vitamin A in the intervention group. The programme did not have a significant impact on calorie, sugar, or fat consumption.
Conclusions: The HFN programme is effective in mitigating some of the negative impacts of the nutrition transition on dietary adequacy among Inuit and Inuvialuit women of childbearing age.

Introduction

During a woman's childbearing years, a healthy diet is important because poor nutrition presents significant risks to reproductive health. Maternal micronutrient status can influence the risk of pregnancy complications and result in poor foetal growth and development [World Health Organization/Food and Agriculture Organization (WHO/FAO), 2004; De Wals *et al.*, 2008]. For example, maternal folate deficiency before conception and during the first few weeks of pregnancy may cause neural tube defects such as spina bifida and anencephaly (WHO/FAO, 2004). Obesity and other symptoms of overconsumption can also have adverse effects on reproductive health, causing reduced fertility and an increased risk of complications in gestation, childbirth and post-partum (Zaadstra

et al., 1993; Kmetic *et al.*, 2008; Baron *et al.*, 2010). Obesity and micronutrient deficiencies during gestation may also be predictors for a child's development of chronic disease later in life (Martorell *et al.*, 2001; Christian & Stewart, 2010).

The nutrition transition (Popkin, 2006) has compromised the diet of indigenous populations inhabiting the Canadian Arctic (Kuhnlein *et al.*, 2004) and women of childbearing age are not exempt from these effects. Recent studies of Aboriginal populations living in Northern Canada have documented a high energy intake and obesity prevalence, and a low intake of many nutrients, including dietary fibre, total folate, and vitamins A and D (Sharma *et al.*, 2009). Store-bought foods of low nutritional quality have been shown to constitute the greatest proportion of this population's diet, whereas more nutrient dense nutritious foods, such as traditional animal source foods, fruits and vegetables, were consumed to lesser degrees (Gittelsohn *et al.*, 2010; Sharma, 2010).

The Healthy Foods North (HFN) programme sought to improve diet and increase physical activity among Inuit and Inuvialuit populations with the aim of preventing chronic disease (Gittelsohn *et al.*, 2010; Sharma, 2010). Based on themes identified during community participatory research (Gittelsohn *et al.*, 2010; Sharma, 2010), the main objectives aiming to improve diet included increasing the consumption of traditional foods (e.g. caribou, seal, fish) and nutrient-dense store-bought foods low in fat and sugar (e.g., fruits, vegetables), and decreasing the consumption of non-nutrient-dense, high fat and/or high sugar foods (e.g. soda, chips). For example, specific themes included the promotion of healthy breakfasts, healthier meal planning, and obtaining sufficient vitamins and minerals. The programme was implemented in local food stores, health clinics, offices, and at community special events, such as feasts. Community media, such as radio, local television, newspapers and other community communication channels, also promoted programme messages (Sharma, 2010).

The objective of the present study was to assess the effect of HFN on diet quality and dietary adequacy among Inuit and Inuvialuit women of childbearing age in Nunavut and the Northwest Territories (NWT), respectively.

Materials and methods

Setting

The present study evaluated the impact of a community-based intervention trial (HFN) conducted in six communities in Nunavut ($n = 3$) and the NWT ($n = 3$). Improvements in healthy eating (e.g. high fibre and vitamin A and D intake and low fat and sugar intake) and physical activity post-intervention were the primary outcomes of HFN. Communities were selected for participation because they represented varying percentages of Inuit or Inuvialuit populations and socioeconomic status. Two remote communities in Nunavut received the intervention from October 2008 to November 2009, and one semi-remote and one remote community in the NWT received it from May 2008 to August 2009. Two additional remote communities (one each in Nunavut and the NWT) served as comparison controls, receiving delayed intervention after the completion of post-intervention data collection.

The community populations have been described previously (Sharma, 2010). In brief, the Nunavut communities range in population from 800 to 1500 people, 80–90% of whom self-identify as Inuit. The median Inuit age ranges from 20 to 26 years, employment rate ranges from 40% to 60%, and the median household income is CAN $34 000–60 000 (Statistics Canada, 2006). One Nunavut community is a regional centre with a larger non-indigenous population and greater engagement in the wage economy than the other two. The three communities in the NWT range from 400 to 3500 people, with Inuvialuit populations ranging from 40% to 90%. The median age of Inuvialuit in these communities ranges from 24 to 26 years, employment is 40–65% and median household income is CAN$33 000–64 000 (Statistics Canada, 2006). Each of the six communities has two to three food stores that obtain food primarily through shipments from the south via airplane year round, via roads and/or ice roads for part of the year, and via barge or sea lift once per year when the sea ice melts. As a result of high transportation and storage costs, the price of food is elevated compared to prices in southern Canada (Indian & Northern Affairs Canada, 2011). Food is also obtained (to varying degrees) by traditional means (e.g. hunting, fishing, food sharing networks).

Data collection

Individuals from participating communities were recruited to monitor the effect of the intervention over a year-long period. Data collection was carried out at two time points in each community; baseline and 12-months (post-intervention). Participant recruitment and baseline data collection were carried out in Nunavut between June and October 2008, and in the NWT between July 2007 and July 2008. Participants were recruited by random selection using up-to-date community housing maps provided by local Hamlets. The first house was randomly selected based on information from the map. The recruitment continued from every other tenth consecutive house. If nobody was available in the randomly selected

house after three attempts, the next house was chosen. A random house was substituted if the eligible subject from the initially selected house declined to participate. This method ensured sampling from areas with varied proximities to food stores. One resident per household (ideally the person who was the main food shopper/preparer) was recruited. Exclusion criteria included pregnant/lactating women, as a result of this population groups' different nutritional requirements and possible changes in dietary habits. Informed consent was obtained from all study participants. Baseline response rates in the Nunavut communities ranged from 69% to 93% and 65% to 85% in the NWT. The present study reports results only from women participants of childbearing age (19–44 years). Follow-up data collection was completed during October to December 2009 in the NWT, and October to November 2009 in Nunavut. Of the total of 136 women interviewed at baseline, 100% completed the follow-up.

Pre- and post-intervention data were collected by local community health workers, community members and university students, all of whom were trained by the principal investigator. Anthropometric measurements (height and weight) were obtained in duplicate and recorded on an additional anthropometry form. Heights were recorded to the nearest centimeter using a stadiometer, and weights were recorded to the nearest 0.1 kg using a digital scale. Before being measured, participants were asked to remove shoes and heavy outer clothing (such as jackets). Weight was adjusted for clothing: 1 kg for light clothing, 1.5 kg for medium-weight clothing and 2 kg for heavy clothing. Culturally appropriate quantitative food frequency questionnaires (QFFQ) were used to assess dietary intake at both time points. These QFFQs were previously developed and validated specifically for Inuit and Inuvialuit populations and were designed to assess dietary intake in the respective communities (Sharma *et al.*, 2009, 2010; Pakseresht & Sharma, 2010a,b). Participants were asked to report the frequency of consumption over a 30-day period, choosing from eight categories, which ranged from 'never' to 'two or more times per day'. Portion size models were provided to increase participants' accuracy of quantification. To approximate socioeconomic status, a questionnaire was administered to collect information on sociodemographic variables and material style of life (MSL), which was an additive scale of ownership of 20 items in working condition (baseline Cronbach's $\alpha = 0.83$; follow-up Cronbach's $\alpha = 0.84$). Description of the questionnaire has been reported previously (Mead *et al.*, 2010). Data collectors interviewed participants in their homes and the majority of interviews were conducted in English. For participants whose primary language was not English, either an interviewer fluent in the local language conducted the survey or an interpreter was used. Interviewers/interpreters had been trained by the investigators to ensure standardisation.

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. The Ethics Committee of the Beaufort Delta Health and Social Services Authority and the Aurora Research Institute in the NWT and the Nunavut Research Institute provided research licences. Participants were reimbursed for their time with gift cards for use at local stores for $25 Canadian.

Statistical analysis

Baseline differences in mean values and proportions of the demographic and socioeconomic variables between communities by intervention assignment were analysed using a Student's *t*-test for continuous normally distributed variables and a chi-squared test for categorical variables.

The mean (SD) of daily energy and selected nutrient intakes was calculated for all participants at pre- and post-intervention time points. To determine diet quality, nutrient densities per 4184 kJ (1000 kcal) were determined by dividing each participant's daily nutrient intake by the energy intake (kJ), multiplied by 4184. Participants who reported extreme energy intake at either time point (>29288 kJ; $n = 19$) were excluded from the analysis. No participant reported an energy intake of <2092 kJ. Considering normal distribution of data, a paired *t*-test was used to examine the null hypothesis of identical mean nutrient intake between post- and pre-intervention stages for both the intervention and control groups.

The change in post- to pre-intervention daily intake was determined for each nutrient and each participant (subtraction of pre-intervention value from post-intervention value). A positive change in intake of a specific nutrient indicated a higher intake of the nutrient in post- compared to pre-intervention. Dietary adequacy was determined by comparing individuals' intakes to the estimated average requirements (EAR) for sex and age groups (Lawn *et al.*, 1998). If the EAR was not available, as for dietary fibre, pantothenic acid, potassium and sodium, the adequate intake (AI) was used instead because both EAR and AI are components of daily recommended intakes (DRI).

Analysis of covariance (ANCOVA), comprising the preferred method for comparing baseline and follow-up numerical variables in experimental studies (Vickers & Altman, 2001), was used to examine the intervention

effect. Post-intervention nutrient intakes were regressed on a series of independent variables, which included intervention assignment, baseline nutrient intake, age, education, MSL, percentage of household on income support and employment status. Nutrients incorporated in the model included those of interest to be promoted (dietary fibre, vitamins A and D, total folate) or de-promoted (fat and sugar), as well as those that had significant change from pre- to post-intervention (saturated fat, vitamin K and potassium).

Data were analysed using STATA, version 11 (StataCorp LP, College Station, TX, USA). To reduce the chances of obtaining false-positive results (type I errors) by performing multiple pair wise tests on the study data, all *P*-values were considered statistically significant at $\alpha < 0.01$.

Results

The participants consisted of 136 women of childbearing age with a mean (SD) age of 35.4 (6.5) years. Of these, 79 women were in the intervention group and 57 were in the control group. Baseline demographic characteristics are presented by treatment group in Table 1. The intervention and control groups were similar in characteristics such as age, MSL, level of education and percentage of households working. Participants in both the intervention and control group displayed a broad range of MSL scores (from 2 to 19) and education levels (from no education to university completed).

Table 1 Comparison of demographic information of intervention and control groups at baseline

	Intervention (n = 79)		Control (n = 57)		
	Mean	(SD)	Mean	(SD)	*P*-value
Age (years)	34.56	(6.90)	36.39	(5.92)	0.09
Education, *n* (%)*					
Low	25	(32.47)	19	(33.33)	0.55
Medium	36	(46.75)	23	(40.35)	
High	16	(20.78)	15	(26.32)	
Material style of life, *n* (%)†					
Low	25	(32.47)	18	(31.58)	0.96
Medium	24	(31.17)	19	(33.33)	
High	28	(36.36)	20	(35.09)	
Household members on income support, *n* (%)					
None	43	(54.43)	23	(40.35)	0.10
≥1	36	(45.57)	34	(59.65)	
Household members working, *n* (%)					
None	20	(25.32)	13	(22.81)	0.73
≥1	59	(74.68)	44	(77.19)	

*Low: none, some elementary school, elementary school completed, some junior high school; Medium: junior high school completed, some high school, high school completed; High: some college or trade school, college or trade school completed, some university, university completed.

†Low 0–7; medium 8–12; high 13–20.

Mean energy and nutrient intakes before and after the intervention, as well as the post- to pre- intervention changes for each intervention and control groups, are presented in Table 2. All statistically significant differences in mean daily intakes were related to post-intervention reduction in sugar and vitamin K intakes (in intervention group) and omega-6 fatty acid, vitamins E and K, and potassium intake (in control group).

Table 3 presents the mean (SD) nutrient density values for the intervention and control groups and the post- to pre-intervention changes. In the intervention group, saturated fat and vitamin K were consumed to a lesser degree for each 4184-kJ daily energy intake. For the control group, only a reduction in intake of potassium was observed post- compared to pre-intervention for each 4184-kJ daily energy intake.

Examination of adherence to dietary reference intake showed that more than 70% of people in both intervention and control groups did not meet the recommended daily intake of dietary fibre and vitamins D and E (Table 4). The percentage of individuals with nutrient intakes below the EAR or AI increased from pre- to post-intervention for all nutrients except for vitamin B_{12} (1.3–0.0%), vitamin D (89.9–83.5%) and zinc (8.9–6.3%) in the intervention group. In the control group, the pre- to post-intervention situation of adherence to dietary reference intake remained unchanged for four nutrients (vitamins B_{12} and E, iron and zinc) and the proportion of people reporting dietary fibre intake lower than AI decreased post-intervention (85.9–82.5%). However, for the majority of other nutrients, the results showed poorer adherence to dietary reference post-intervention in the control compared to the intervention group. Differences between percentage point changes in the intervention and the control group represented an improvement of adherence to the dietary reference for vitamins A, D and K, calcium, magnesium, potassium, sodium and zinc (18.6%, 11.7%, 4.9%, 14.0%, 6.8%, 8.2%, 6.3% and 2.6% reduction in the proportion of population below EAR/AI, respectively) for the intervention group.

ANCOVA (Table 5) showed a positive impact of the intervention for the intake of vitamin A (β = 558.23, 95% confidence interval = 179.86–936.59) and vitamin D (β = 89.23, 95% confidence interval = 3.86–174.60). For energy and other nutrients included in the models, the difference between changes for the intervention group was not statistically significant compared to the control group.

Table 2 Mean and standard deviation (SD) of nutrient intake/day by treatment group, and difference in pre- to post-intervention

Nutrients	Intervention (n = 79)						Control (n = 57)					
	Pre		Post			Change post to pre intervention (95% CI)	Pre		Post			Change post to pre intervention (95% CI)
	Mean	SD	Mean	SD	*P**		Mean	SD	Mean	SD	*P**	
Energy (kJ)	13 430	6058	12 305	5606	0.12	−1121 (−2535, 289)	13 430	4607	12 502	5468	0.23	−929 (−2468, 611)
% energy from protein	18.80	7.08	19.77	5.91	0.22	0.97 (−0.60, 2.54)	21.30	5.45	20.34	5.67	0.36	−0.96 (−3.07, 1.14)
% energy from CHO	48.34	8.42	48.01	7.76	0.73	−0.33 (−2.25, 1.60)	48.19	8.15	50.59	9.38	0.17	2.41 (−1.05, 5.86)
% energy from fat	31.32	5.97	29.83	4.46	0.04	−1.49 (−2.94, −0.04)	29.13	4.27	27.55	5.40	0.08	−1.58 (−3.39, 0.21)
% energy from alcohol	1.62	3.41	2.64	4.36	0.08	−1.02 (−0.12, 2.16)	1.18	3.12	1.50	3.37	0.38	0.32 (−0.41, 1.06)
Protein (g)	151.84	91.20	147.26	85.81	0.67	−4.58 (−25.89, 16.73)	172.79	81.58	155.74	93.17	0.26	−17.05 (−46.76, 12.65)
Carbohydrate (g)	392.93	211.11	350.41	165.04	0.07	−42.52 (−87.77, 2.74)	382.61	138.08	370.98	163.67	0.63	−11.63 (−59.41, 36.16)
Sugars (g)	201.06	142.54	160.10	82.65	0.009	−40.96 (−73.30, −8.61)	187.14	85.41	176.27	129.74	0.57	−10.87 (−49.21, 27.47)
Dietary fiber (g)	17.72	9.83	16.91	9.59	0.51	−0.81 (−3.21, 1.60)	16.85	7.67	16.10	8.21	0.58	−0.75 (−3.46, 1.96)
Fat (g)	110.41	52.59	98.30	50.21	0.08	−12.11 (−25.77, 1.56)	104.76	42.58	92.78	50.80	0.13	−11.98 (−27.50, 3.54)
Saturated fat (g)	38.34	17.49	32.85	17.47	0.01	−5.50 (−10.04, −0.96)	34.77	14.14	30.84	16.93	0.12	−3.93 (−8.90, 1.04)
Monounsaturated fat (g)	38.38	18.60	34.17	18.86	0.10	−4.21 (−9.31, 0.88)	37.20	16.21	32.16	18.19	0.08	−5.04 (−10.71, 0.63)
Polyunsaturated fat (g)	17.24	10.76	14.94	7.89	0.10	−2.31 (−5.05, 0.44)	17.34	7.80	14.12	8.10	0.01	−3.22 (−5.72, −0.72)
Omega-3 fatty acid (g)	1.70	1.15	1.85	1.57	0.46	0.15 (−0.25, 0.55)	1.99	1.05	1.61	1.15	0.06	−0.38 (−0.76, 0.01)
Omega-6 fatty acid (g)	15.55	13.99	12.52	7.06	0.06	−3.04 (−6.21, 0.14)	14.47	7.90	11.29	6.61	0.006	−3.17 (−5.39, −0.96)
Cholesterol (mg)	544.38	405.92	460.75	268.68	0.07	−83.63 (−175.33, 8.05)	459.59	208.89	464.30	295.44	0.90	4.71 (−73.40, 82.81)
Vitamin A (μg-RAEs)	909.15	734.09	1099.42	1327.97	0.22	190.27 (−115.07, 495.60)	770.72	482.27	620.55	487.58	0.09	−150.17 (−325. 09, 24.74)
Thiamin (mg)	2.33	1.29	2.30	1.22	0.83	−0.03 (−0.33, 0.27)	2.64	1.18	2.55	1.27	0.67	−0.09 (−0.51, 0.33)
Riboflavin (mg)	4.31	2.39	3.85	1.73	0.08	−0.47 (−0.98, 0.05)	4.46	1.87	4.21	1.99	0.46	−0.24 (−0.89, 0.40)
Niacin (mg)	37.45	20.50	35.98	19.94	0.56	−1.47 (−6.42, 3.49)	40.07	16.15	39.91	20.32	0.96	−0.16 (−6.44, 6.13)
Pantothenic acid (mg)	11.00	6.55	9.66	4.60	0.06	−1.35 (−2.77, 0.08)	11.11	4.99	11.01	5.91	0.92	−0.10 (−1.93, 1.73)
Vitamin B_6 (mg)	2.53	1.35	2.31	1.11	0.21	−0.21 (−0.55, 0.12)	2.53	1.31	2.44	1.19	0.68	−0.09 (−0.54, 0.35)
Total folate (μg)	431.97	200.06	430.36	237.95	0.95	−1.55 (−55.27, 52.16)	460.56	225.71	420.41	203.42	0.25	−40.15 (−109.75, 29.45)
Vitamin B_{12} (μg)	16.18	16.35	16.28	12.10	0.96	0.10 (−3.64, 3.83)	16.88	10.53	18.23	12.85	0.51	1.35 (−−2.73, 5.43)
Vitamin C (mg)	206.99	133.50	194.15	130.33	0.48	−12.84 (−49.07, 23.40)	195.95	149.04	177.97	136.16	0.45	−17.98 (−65.62, 29.67)
Vitamin D (IU)†	201.55	140.59	251.13	290.50	0.17	49.58 (−21.30, 120.45)	238.96	240.26	158.69	127.66	0.01	−80.26 (−147.15, −13.37)
Vitamin E (mg)‡	2.30	6.11	1.36	1.86	0.13	−0.94 (−2.17, 0.30)	1.83	2.29	1.03	1.27	0.008	−0.81 (−1.40, −0.22)
Vitamin K (μg)	155.45	114.54	102.09	53.90	0.001	−53.36 (−79.23, −27.49)	143.38	126.61	99.12	73.10	0.009	−44.26 (−78.66, −9.87)
Iron (mg)	27.05	17.12	27.55	16.74	0.78	0.51 (−3.04, 4.05)	31.36	15.88	29.42	17.25	0.48	−1.94 (−7.38, 3.51)
Calcium (mg)	1252.33	670.56	1134.89	710.65	0.17	−117.45 (−285.83, 50.94)	1386.70	881.20	1154.61	635.29	0.08	−232.09 (−488.57, 24.38)
Magnesium (mg)	382.97	172.09	356.03	165.32	0.17	−26.94 (−65.35, 11.47)	413.49	144.86	361.37	185.89	0.05	−52.12 (−105.22, 0.98)
Potassium (mg)	4104.79	1864.34	3726.47	1807.97	0.08	−378.32 (−805.12, 48.49)	4512.11	1722.82	3743.31	1852.46	0.009	−768.8 (−1340.09, −197.51)
Sodium (mg)	4576.60	2419.50	4485.73	2784.50	0.79	−90.87 (−767.33, 585.58)	4887.82	2152.10	4294.56	2635.57	0.17	593.26 (− 1451.42, 264.90)
Selenium (μg)	158.14	84.43	171.53	156.13	0.47	13.39 (−23.38, 50.16)	170.01	82.95	153.79	96.62	0.26	16.22 (−44.58, 12.15)
Zinc (mg)	20.99	12.26	19.63	10.82	0.38	−1.36 (−4.43, 1.70)	21.71	11.01	21.45	12.57	0.89	−0.27 (−4.19, 3.65)

**P*-value for paired *t*-test.

†As cholecalciferol.

‡As alpha–tocopherol.

CI, confidence interval; IU, international units; RAEs, retinol activity equivalents.

Table 3 Mean and standard deviation (SD) of daily nutrient density (per 4184 kJ) by treatment group, and difference in pre- to post-intervention

	Intervention (n = 79)						Control (n = 57)					
	Pre		Post				Pre		Post			
Nutrients	Mean	SD	Mean	SD	P*	Change post to pre intervention (95% CI)	Mean	SD	Mean	SD	P*	Change post to pre intervention (95% CI)
Protein (g)	47.00	17.69	49.43	14.76	0.22	2.42 (−1.50, 6.35)	53.25	13.62	50.84	14.17	0.36	−2.41 (−7.68, 2.85)
Carbohydrate (g)	120.84	21.06	120.02	19.40	0.73	−0.82 (−5.64, 3.99)	120.47	20.39	126.48	23.46	0.17	6.02 (−2.62, 14.65)
Sugars (g)	61.70	23.13	55.96	21.13	0.05	−5.74 (−11.46, −0.01)	59.21	20.74	60.26	29.54	0.83	1.05 (−8.81, 10.91)
Dietary fiber (g)	5.60	2.07	5.86	1.81	0.24	0.27 (−0.18, 0.72)	5.26	1.56	5.46	1.73	0.46	0.20 (−0.33, 0.74)
Fat (g)	34.80	6.63	33.14	4.96	0.04	−1.66 (−3.27, −0.04)	32.37	4.74	30.61	6.00	0.08	−1.76 (−3.76, 0.24)
Saturated fat (g)	12.22	2.83	11.15	2.36	0.002	−1.07 (−1.75, −0.39)	10.85	2.01	10.25	2.19	0.06	−0.60 (−1.24, 0.03)
Monounsaturated fat (g)	12.20	2.84	11.46	2.34	0.02	−0.74 (−1.38, −0.10)	11.43	2.15	10.61	2.52	0.06	−0.83 (−1.71, 0.05)
Polyunsaturated fat (g)	5.41	1.89	5.12	1.60	0.21	−0.29 (−0.74, 0.16)	5.28	1.25	4.72	1.52	0.02	−0.56 (−1.04, −0.08)
Omega-3 fatty acid (g)	0.54	0.25	0.60	0.35	0.10	0.07 (−0.01, 0.14)	0.60	0.22	0.52	0.26	0.10	−0.08 (−0.17, 0.01)
Omega-6 fatty acid (g)	4.81	2.53	4.39	1.84	0.13	−0.42 (−0.97, 0.13)	4.34	1.55	3.83	1.41	0.02	−0.51 (−0.94, −0.07)
Cholesterol (mg)	172.45	110.80	157.73	61.87	0.25	−14.73 (−40.15, 10.70)	144.56	51.09	155.36	64.55	0.25	10.80 (−7.76, 29.37)
Vitamin A (μg-RAEs)	301.90	221.84	364.47	286.39	0.10	62.59 (−12.15, 137.33)	255.37	179.53	202.00	93.34	0.06	−53.37 (−108.54, 1.80)
Thiamin (mg)	0.73	0.21	0.79	0.18	0.03	0.06 (0.01, 0.11)	0.83	0.21	0.87	0.28	0.16	0.05 (−0.02, 0.12)
Riboflavin (mg)	1.39	0.55	1.37	0.38	0.76	−0.02 (−0.16, 0.12)	1.41	0.41	1.47	0.47	0.46	0.05 (−0.09, 0.19)
Niacin (mg)	11.64	3.23	12.23	2.91	0.18	0.59 (−0.27, 1.47)	12.59	3.17	13.58	4.37	0.13	0.99 (−0.29, 2.27)
Pantothenic acid (mg)	3.58	1.58	3.47	1.19	0.54	−0.11 (−0.48, 0.25)	3.54	1.27	3.82	1.53	0.24	0.27 (−0.19, 0.74)
Vitamin B_6 (mg)	0.79	0.22	0.81	0.21	0.51	0.02 (−0.04, 0.07)	0.79	0.25	0.84	0.26	0.24	0.05 (−0.03, 0.13)
Total folate (μg)	140.03	42.17	149.82	47.25	0.11	9.79 (−2.43, 22.01)	145.26	46.96	147.30	54.19	0.78	2.04 (−12.77, 16.86)
Vitamin B_{12} (μg)	4.80	4.05	5.59	3.34	0.13	0.79 (−0.24, 1.83)	5.25	2.75	6.14	3.39	0.09	0.89 (−0.15, 1.93)
Vitamin C (mg)	64.66	36.30	65.99	36.76	0.78	1.33 (−7.95, 10.61)	62.50	45.46	60.70	37.75	0.81	−1.80 (−16.55, 12.95)
Vitamin D (IU)†	67.30	45.14	85.07	82.95	0.10	17.77 (−3.22, 38.76)	75.12	71.45	53.00	36.33	0.03	−22.12 (−41.60, −2.63)
Vitamin E (mg)‡	0.61	1.10	0.49	0.67	0.28	−0.12 (−0.34, 0.10)	0.53	0.61	0.37	0.47	0.05	−0.17 (−0.33, 0.00)
Vitamin K (μg)	56.85	51.98	40.11	25.19	0.004	−16.74 (−28.01, −5.46)	46.74	40.99	36.49	26.22	0.07	−10.25 (−21.48, 0.99)
Iron (mg)	8.35	3.59	9.31	3.28	0.02	0.96 (0.19, 1.74)	9.62	2.68	9.78	2.87	0.72	0.15 (−0.71, 1.02)
Calcium (mg)	400.13	160.54	392.06	150.42	0.72	−8.06 (−53.16, 37.03)	430.03	161.49	388.25	135.49	0.09	−41.77 (−90.66, 7.11)
Magnesium (mg)	123.67	31.65	125.88	31.41	0.51	2.22 (−4.43, 8.87)	130.42	25.23	121.89	29.89	0.05	−8.53 (−16.89, −0.17)
Potassium (mg)	1332.83	382.26	1312.87	369.07	0.60	−19.96 (−95.96, 56.05)	1418.78	321.25	1264.54	283.29	0.002	−154.23 (−250.73, −57.73)
Sodium (mg)	1412.65	331.21	1503.89	466.10	0.12	91.24 (−23.33, 205.81)	1552.67	551.39	1404.73	412.25	0.12	−147.93 (−335.02, 39.15)
Selenium (μg)	51.24	23.51	56.08	27.60	0.17	4.84 (−2.17, 11.86)	53.72	21.15	51.82	22.76	0.65	−1.90 (−10.20, 6.41)
Zinc (mg)	6.57	2.40	6.76	2.14	0.54	0.19 (−0.43, 0.81)	6.67	2.05	7.08	2.26	0.28	0.41 (−0.34, 1.17)

*P-value for paired t-est.

†As cholecalciferol.

‡As alpha–tocopherol.

CI, confidence interval; IU, international units; RAEs, retinol activity equivalents.

Table 4 Percentage and percentage change of participants with nutrient intake below the dietary reference intakes* by treatment group

	Intervention			Control			Change in intervention versus change in control†
Nutrients	Pre (n = 79)	Post (n = 79)	Change post- to pre-intervention	Pre (n = 57)	Post (n = 57)	Change post- to pre-intervention	Difference (%)
Dietary fibre	77.2	85.0	7.8	85.9	82.5	−3.4	11.2
Total folate (DFE)	31.6	36.7	5.1	26.3	33.3	7	−1.9
Vitamin A (RAE)	20.3	22.8	2.5	22.8	43.9	21.1	−18.6
Vitamin B_6	8.9	13.9	5	7.0	10.5	3.5	1.5
Thiamin	3.8	11.4	7.6	3.5	7.0	3.5	4.1
Niacin	2.5	3.8	1.3	1.8	3.5	1.7	−0.4
Pantothenic acid	7.6	13.9	6.3	8.8	10.5	1.7	4.6
Vitamin B_{12}	1.3	0.0	−1.3	0.0	0.0	0	−1.3
Vitamin C	13.9	18.9	5	14.0	19.3	5.3	−0.3
Vitamin D‡	89.9	83.5	−6.4	87.7	93.0	5.3	−11.7
Vitamin E§	97.5	98.7	1.2	100.0	100.0	0	1.2
Vitamin K	34.2	46.8	12.6	35.1	52.6	17.5	−4.9
Calcium	31.6	31.6	0	21.1	35.1	14	−14
Iron	5.1	8.9	3.8	0.0	0.0	0	3.8
Magnesium	26.1	31.6	5.5	17.5	29.8	12.3	−6.8
Potassium	65.8	73.4	7.6	59.6	75.4	15.8	−8.2
Sodium	3.8	6.3	2.5	0.0	8.8	8.8	−6.3
Selenium	2.5	3.8	1.3	1.8	3.5	1.7	−0.4
Zinc	8.9	6.3	−2.6	5.3	5.3	0	−2.6

*Estimated average requirement was used for all nutrients except dietary fibre, pantothenic acid, potassium, and sodium that were compared with adequate intake.

†Change = (% post-intervention – % pre-intervention in intervention group) – (% post-intervention – % pre-intervention in control group).

‡As cholecalciferol. In the absence of adequate exposure to sunlight.

§As α-tocopherol.

DFE, dietary folate equivalent; RAE, retinol activity equivalent.

Discussion

The results obtained in the present study indicate that the HFN intervention had a beneficial effect on the dietary intake of certain micronutrients in Inuit and Inuvialuit women of childbearing age. Exposure to the intervention increased the overall intake of vitamins A and D. A nutritious diet is important for women of childbearing age becuse it can help ensure both the current health of a population and of its future generations. A diet that fails to provide adequate amounts of nutrients may increase the risk of nutrient deficiency, which, if present in a woman at conception and/or during pregnancy, can have devastating impacts on maternal health and/or foetal growth and development.

Dietary assessment before the implementation of HFN showed that a number of nutrients with key roles in foetal development (e.g. vitamins A and D and total folate) were consumed below adequate levels by 20–90% of women of childbearing age. Similar patterns were also found among the general population (WHO/FAO, 2004; Erber *et al.*, 2010; Hopping *et al.*, 2010). The vitamin A intake for Inuit women has been reported to be as low as 26–87% of Health Canada's Recommended Nutrient Intake (Lawn *et al.*, 1998). Vitamins A and D are some of the nutrients found in high amounts in these populations' traditional foods which are mainly animal and fish sources; (Kuhnlein *et al.*, 2004). A close examination of the effect of the HFN intervention on food consumption patterns is beyond the scope of the present study. Briefly, a food group analysis showed a 95 g day^{-1} (95% confidence interval = −36 to 225) difference between the intervention and control groups for the pre- to post-intervention change in traditional food intake, suggesting an overall improvement in traditional food intake in the intervention compared to the control group, although this was not statistically significant. Therefore, it is possible that at least part of the improvement in vitamins A and D intakes observed in the present study is attributable to an increase in traditional food consumption with the intervention because traditional foods were included as a target food group of the HFN programme.

Vitamin A deficiency is uncommon in the developed world but is endemic to many developing countries (van den Broek *et al.*, 2010). However, the present study found that less than 80% of Inuit and Inuvialuit women

Table 5 Impact of the Healthy Foods North intervention programme on post-intervention nutrient consumption

Nutrients	Difference between changes	95% CI	Nutrients	Difference between changes	95% CI
Energy (kj)	−75	−1929, 1782	Omega-6 fatty acid (g)	0.90	−1.56, 3.35
Protein (g)	5.48	−25.38, 36.34	Vitamin A (μg)	558.23	179.86, 936.59
Fat (g)	6.00	−11.54, 23.54	Vitamin D (IU)	89.23	3.86, 174.60
Carbohydrate (g)	−28.07	−83.59, 27.44	Total folate (μg)	22.17	−53.46, 97.79
Sugar (g)	−24.18	−62.46, 14.10	Calcium (mg)	15.61	−221.68, 252.90
Dietary fibre (g)	0.67	−2.45, 3.79	Iron (mg)	1.47	−4.12, 7.05

CI, confidence interval.

consumed adequate amounts of this nutrient. Important dietary sources of vitamin A for these women include traditional seafoods (Lucas *et al.*, 2008); this emphasises the importance of incorporating traditional foods into the daily diet of these populations. ANCOVA analysis showed that the HFN programme had a significant impact on intake of vitamin A in women of childbearing age after controlling the effect of baseline intake, age and socioeconomic variables. This impact was equal to 558 μg day^{-1}, which is more than the Canadian EAR level (500 μg day^{-1}). Vitamin A deficiency is particularly concerning in women of childbearing age because it is essential for cell differentiation and the development of many foetal organ systems, including the reproductive, visual, pulmonary, immune and epithelial systems (Checkley *et al.*, 2010; Simpson *et al.*, 2011). Inadequate maternal vitamin A has been associated with maternal anaemia, post-natal infection and night blindness (van den Broek *et al.*, 2010). Vitamin A supplementation in deficient women during the pregnancy and breastfeeding period has been shown to improve outcomes for the mother and child and is recommended (van den Broek *et al.*, 2010).

Vitamin D deficiency and insufficiency is very common in individuals living at high latitudes, such as indigenous women in Northern Canada, because this population produces very little vitamin D cutaneously from ultraviolet exposure (Kulie *et al.*, 2009). The present study found that the diet of Inuit and Inuvialuit women was partly lacking in vitamin D and that the dietary intervention improved intake of this nutrient. This improvement (89 IU day^{-1}) was less than the Canadian EAR level (400 IU day^{-1}); however, this level of improvement can be important considering the short period of intervention and the importance of the consequences of vitamin D deficiency. The evidence for the dangers of vitamin D deficiency in women of childbearing age is mounting. Vitamin D deficiency and insufficiency is associated with many chronic diseases, including cancer, diabetes, cardiovascular disease, rickets, multiple sclerosis, osteoporosis and schizophrenia (Lucas *et al.*, 2008; Kulie *et al.*, 2009). Pregnant women are at an increased risk of developing complications such as gestational diabetes if their vitamin D status is inadequate; in addition, the developing foetus may experience an increased risk of problems with respect to intrauterine skeletal mineralisation and the development of chronic diseases later in life (Lucas *et al.*, 2008; Lewis *et al.*, 2010; Mulligan *et al.*, 2010; Viljakainen *et al.*, 2010).

Although the mean intake of vitamins A and D increased, partly as a result of the HFN programme, the percentage of individuals in the intervention group below the EAR level increased during the intervention by 2.5% for vitamin A intake but decreased by 6.4% for vitamin D. The opposite results were observed for vitamin A intake and any adherence to the EAR should not be misinterpreted as a discrepancy because, first, the overall increment obtained with respect to a vitamin A intake of 558 μg day^{-1} was based on a regression model including both the intervention and control groups and controlled for the effect of baseline vitamin A intake, age and other factors. This finding should be interpreted independent from the output of a simple analysis of percentage of individuals below the EAR. Second, the intervention may have resulted in an increased intake of vitamin A for individuals who were previously consuming amounts far below the dietary reference intakes, such that mean intake of vitamin A increased significantly during the intervention. However, for other individuals, seasonal changes in diet may have resulted in a decreased vitamin intake compared to baseline. Seasonal dietary variation may also explain the similar pattern of intake and deficiency for vitamin D. This finding highlights the need for further investigations into the particular foods being consumed pre- and post-intervention, as well as their vitamin A and D content.

Baseline assessment in this population of women of childbearing age revealed that, on average, energy intake was excessive. Therefore, a reduction in energy intake was a desirable outcome in the present study because of the negative impact that obesity and diabetes can have on fertility and pregnancy outcomes (Zaadstra *et al.*, 1993; Kmetic *et al.*, 2008; Baron *et al.*, 2010). Although energy intake decreased more in the intervention group

compared to the control group, the results were not statistically significant. No significant change in post- compared to pre-intervention intake of most of the other nutrients was also observed in the pairwise tests. This may be attributed to the small sample size of participants. Some interventions on North American indigenous adults and children have shown improvements in dietary intake in terms of decreased fat and total energy intake (Caballero *et al.*, 2003; Himes *et al.*, 2003) or an increased consumption of healthy foods (i.e. fruits and vegetables; Thompson *et al.*, 2008), although these studies observed these effects after 3-year study periods. Therefore, it can be expected that, with ongoing HFN implementation in these Arctic communities, the positive intervention response will increase further over time.

Certain demographic factors were found to be related to fat intake by linear regression. Given that one of the goals of HFN was to increase intake of traditional foods, the positive but nonsignificant association observed may reflect that the intervention increased the intake of traditional protein sources containing substantial amounts of animal oils. Because a higher MSL score generally indicates a higher income level, the relationship suggests that high income levels result in a decreased intake of inexpensive foods consisting largely of fat. This demonstrates that cost of food is a significant barrier to the maintenance of a healthy diet in Arctic Canada.

The HFN programme is a community development approach that integrates combined partnerships of key local and national stakeholders, and includes community participation and capacity-building from intervention development through to the evaluation stage. The WHO/FAO state that effective interventions require the active participation of communities, policy makers, health systems and other important stakeholders (WHO, 2003). Multisector involvement, along with formative research on the Inuit and Inuvialuit diet, as well as traditional and current attitudes and practices, provided a strong basis for the development of a culturally appropriate, evidence-based programme (Gittelsohn *et al.*, 2010). These components collectively contributed an effective intervention with a high likelihood of long-term sustainability (Sallis & Glanz, 2009). As a result of the high cost of healthy eating in the North, where food resources are limited, further investigations into the financial barriers preventing the consumption of a healthy diet are required. This higher food cost highlights the feasibility of incorporating more traditional foods into the daily diet because these are collected through hunting and gathering activities and are less dependent on the Canadian food market.

The present study may have been limited by response bias resulting from an interviewer-administered QFFQ and recall bias, which is a characteristic limitation of FFQs. However, a differential recall bias between participants in the intervention and control groups is less likely because this was a prospective study; thus, any impact on the results would be expected to have attenuated associations (i.e. biased results towards the null). In addition, in these communities, there is a relatively limited selection of foods available for consumption compared to other populations, such as in the U.S. or southern Canada. Therefore, with input from local residents, this instrument's food list was developed to capture most of the foods consumed in these communities, including traditional items and those available only during certain seasons. Also, validation showed that this QFFQ corresponded well with a repeated 24-h recall conducted in the same population (Pakseresht & Sharma, 2010a,b). In theory, a history threat may occur and affect the internal validity of an experimental study in the presence of one or more confounding variables that influence the planned intervention or treatment. In the present study, however, among six variables included in the regression models for ANCOVA analysis, baseline nutrient intake was the only variable that was significantly positively associated with the post-intervention intake of the nutrient (the only exception was for vitamin D; data not shown). Considering the short period of the intervention and the remoteness of communities, the likelihood of intervention contamination is low in the present study.

In conclusion, the nutrition transition has decreased diet quality and nutrient intake among Inuit and Inuvialuit populations. In addition to addressing nutrient deficiencies through food fortification and supplementation protocols, dietary interventions that take a multipronged approach, linking in with national/territorial food policies and community-based programming, could help to address the overall diet of Arctic communities.

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Conflicts of interest, source of funding and authorship

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