Dietary Structure and Relative Health in Inuit Communities

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Abstract

Nutrition is an important contributor to an individual's health. Over the past 50 years, there has been a considerable shift in the diet of indigenous communities, from one which is highly dependent on hunted and gathered food to one that is more reliant on commercial foods. This paper examines the so-called "dietary transition" and the manner in which it has influenced health in Inuit communities. Recent research has shown an increase in consumption of fats from processed foods, which are high in trans-fatty acids, lack key micronutrients found in animals, and contribute to high LDL cholesterol. Consequently, there has been an increase in the incidence of obesity and its co-morbidities, and thus an increase in diet-related chronic disease. Additionally, issues with the dietary transition are compounded for individuals of low socioeconomic status.

Dietary intake has several significant impacts on an individual's health. Most widely acknowledged is the relationship between a poor, energy-dense diet and overweight and obesity (and the subsequent health complications associated with obesity). However, there are also severe health consequences stemming from malnutrition (inappropriate nutrient intake). Technological advances in the production and transportation of food sources have drastically altered the composition of diets in many cultures. In particular, the westernization of indigenous, Arctic communities has resulted in a notable shift in dietary composition over the last 40 to 50 years. Characterized by a decreased reliance on foods that are hunted and gathered in favor of an increased reliance on commercial foods, this mixed diet has subsequently had an important effect on the overall health of Inuit individuals (Jeppesen and Bjerregaard, 2012; Johnson-Down and Egeland, 2012; Sharma et al., 2010;). In light of this so-called 'dietary transition', it is of great value to examine how this adjustment to diet construct has impacted adherence to recommended nutrient intakes and how changes in amount and source of nutrient intake has influenced the overall health in Inuit communities of Northern Canada and Greenland. By investigating what constitutes proper dietary intake, what food types provide these elements, and whether or not these recommendations are being met, this essay explores some factors that influence the ability to achieve dietary adequacy in Inuit communities, as well as the associated health implications.

First, the makeup of an adequate adult diet must be established in order to determine the level of adherence of northern Inuit communities to recommended intake values. The Nordic Nutrition Recommendations (NNR) of 2004 delineate recommended nutrient intakes for normal individuals (lacking uncommon diseases) within Nordic countries. These recommendations serve as a basis to plan a diet that both satisfies nutritional needs (with respect to physiological requirements for growth and function) and enables good overall health, which subsequently decreases an individual's risk of diet-associated diseases (Becker et al., 2004). According to the NNR, the macronutrients in an individual's diet should consist of 15% protein of total energy intake (E%), 55 E% carbohydrates, and 30 E% overall fat (Becker et al., 2004). Additionally, intake of fat should be broken down into the following portions of fat subclasses: 10 E% saturated and trans-fatty acids, 10-15 E% cis-monounsaturated fatty acids, and 5-10 E% polyunsaturated fatty acids. With respect to micronutrients, refined sugars within carbohydrates should not exceed 10 E%, and individuals should consume 25-35 g/d of dietary fiber. Recommended daily allowances for macronutrients and several additional micronutrients are shown in Table 1. Finally, the recommended daily caloric intake for Inuit is 9.6-11.7 MJ/day (approximately 2300-2800 Kcal), with the range accounting for variety in age and sex (Keene, 1985).

		NNR Recommendation		Non-Nordic Recommendation	
Macronutrients					
Protein		15 E%		10-35 E%	
Carbohydrate	Refined Sugar	55 E%	10 E%	45-65 E%	<25 E%
Total Fat	**Saturated and Trans-fatty acids**	30 E%	10 E%	20-35 E%	As little as possible
	Cis-monounsaturated fatty acids		**10-15 E%**		**..**
	Polyunsaturated fatty acids		**5-10 E%**		**5-10 E%**

Micronutrients		
Dietary Fiber	23-35 g	25g
Vitamin A	700-900 µg	700-900 µg
Vitamin D	7.5-10 µg	15 µg
Vitamin E	8-10 mg	15mg
Vitamin B-6	1.2-1.6 mg	2 mg
Vitamin B-12	2.0 µg	6 µg
Vitamin C	75 mg	60 mg
Thiamin	1.0-1.5 mg	1.5 mg
Riboflavin	1.2-1.7 mg	1.7 mg
Niacin	13-20 mg	20 mg
Folate	300 µg	400 µg
Calcium	800-900 mg	1,000 mg
Phosphorous	600-700 mg	1,000 mg
Potassium	3.1-3.5 g	3.5 g
Magnesium	280-350 mg	400 mg
Iron	9-15 mg	18 mg
Zinc	7-12 mg	15 mg
Copper	0.9 mg	2 mg
Iodine	150 µg	150 µg
Selenium	40-50 µg	70 µg

Table 1 *shows the recommended daily intake for a variety of macronutrients and micronutrients. Macronutrients are represented as a portion of the total energy intake (%E), and micronutrients are described in units of grams, milligrams, and micrograms. Recommended intakes are shown for those living in Nordic communities from The Nordic Nutrition Recommendations (NNR) of 2004 as well as non-Nordic communities from the US Food and Drug Administration and Health Canada recommended daily intake guidelines (Becker et al., 2004; fda.gov, 2013; hc-sc.gc.ca; Keene 1985; usda.gov). Ranges of vitamin and mineral values account for the variation in needed intakes due to sex and age.*

Through a review of a variety of literature sources spanning several Inuit populations, it appears that the current, typical Inuit diet is composed of a mix of traditional foods and consumer goods. The most frequently reported traditional foods include caribou, fish (particularly arctic char and trout), seal, and muktuk (frozen whale skin and blubber) (Hopping et al., 2010; Jeppesen and Bjerregaard, 2012; Sharma et al., 2010; Sheehy et al., 2013) while the most frequently reported market food items include coffee and coffee whitener, breads, sugars and honeys, sweetened drinks and sodas, butter and margarine, and chips and sweets (Hopping et al., 2010; Sharma et al., 2010). It was found that store-bought foods are typically consumed more frequently than traditional foods (Hopping et al., 2010; Spiegelaar and Tsuji, 2013; Zotor et al., 2012). This is problematic because these purchased foods are energy dense (i.e. highly caloric) and non-nutrient dense foods, meaning they have reduced nutritional value (Hopping et al., 2010; Huet et al., 2012; Jeppesen and Bjerregaard, 2012; Johnson-Down and Egeland, 2012; Sharma et al., 2010; Sharma et al., 2013; Sheehy et al., 2013).

Furthermore, in general, the modern Inuit diet includes an intake of approximately 8-10 MJ of energy (approximately 1900-2400 Kcal), 21 E% protein, 48 E% carbohydrates, and 32 E% total fat (Jeppesen and Bjerregaard, 2012; Sharma et al., 2010; Sharma et al., 2013). More specifically, the breakdown of total fat consists of 11 E% saturated, 12 E% monounsaturated, 5 E% polyunsaturated, and 3 E% n-3 fatty acid. Approximately 40-50% of protein in the current Inuit diet comes from traditional foods (Sharma et al., 2010; Sharma et al., 2013). The largest intake of energy and fat comes from non-nutrient dense store bought foods such as breads and sweetened beverages (Sharma et al., 2010), contributing to 22% of total fat intake, 42-50% of carbohydrate intake, and 73-80% of sugar intake (Hopping et al., 2010; Sharma et al., 2013). This makes sweetened beverages the largest form of sugar intake (Hopping et al., 2010; Sharma et al., 2010). Overall, primary energy intake comes predominately from juice, caribou and game, and bread, providing 25% of daily energy to individuals (Hopping et al., 2010). In addition to macronutrient contributors, micronutrients are mostly acquired through traditional foods. Traditional food contributes to approximately 41% of fiber intake as well as 49% of Iron intake (Sharma et al., 2010; Sharma et al., 2013). They are also the primary source of Vitamin A and Vitamin B-12 (Hopping et al., 2010).

Despite the adequate proportions of macronutrients intake within the present Inuit diet, there is a clear consensus among the literature that there is a lack of several micronutrients. Micronutrients serve many purposes; they contribute to several important bodily functions such as the breakdown of macronutrients and more specifical-

ly, the maintenance of growth and vision function from vitamin A (Keene, 1985). As such, it is problematic that certain macronutrient components are being obtained in ill-advised ways. For example, though sugars should contribute to a mere 10% of carbohydrate intake, in actuality they contribute to 42-50%. Furthermore, though saturated fat intake is only moderately higher than the recommended intake within total fat construct, it is preferable for the proportion of saturated fat to unsaturated fats to be minimal (Becker et al., 2004). With respect to micronutrients, fiber, folate, calcium, vitamin A, vitamin B-12, vitamin B-6, vitamin D, and vitamin E levels are all consistently lower than recommended intake values in Inuit populations (Hopping et al., 2010; Sharma et al., 2010; Sharma et al., 2013). Most notably, fruits and vegetables contribute to 27% of total fiber intake. Despite this contribution to fiber intake, it is widely reported that there is still a severe deficiency dietary fiber (Hopping et al., 2010; Huet et al., 2012; Johnson-Down and Egeland, 2012; Sharma et al., 2010; Sharma et al., 2013; Sheehy et al., 2013; Spiegelaar and Tsuji, 2013; Zotor et al., 2012).

In contrast to the current Inuit diet, the pre-dietary transition diet consisted of a far greater intake of traditional foods. Resources primarily included caribou, ringed seal, and fish, but were supplemented by muskox, polar bear, bearded seal, birds, hare, wolf, lemming, squirrel, fox, and some berries (Keene, 1979; Sinclair, 1953). Primary resources were most sought after because they provided more optimal returns in terms of hunting time and energy investments to obtain such resources (Keene, 1979). In addition to food provision from hunter-gatherer activity, some food, including bread, flour, barley, peas, sugar, and coffee, was also acquired through imports from Europe (Sinclair, 1953).

The typical prehistoric diet provided approximately 11 MJ (2600 Kcal) total energy, of which the macronutrient content consisted of 60 E% protein, 11 E% carbohydrate, and 29 E% fat (Sinclair, 1953). This constitutes a dramatically high protein diet as compared to the NNR. However, this issue has been examined and there is seemingly no conclusive evidence that high levels of protein contribute to the incidence of diet-related disease in Inuit (Sinclair, 1953). Overall, the literature is in agreement that the previous Inuit diet, which relied on traditional foods, fulfilled the recommendations for daily nutrient intake and surpassed such recommendations with respect to the majority of macro- and micronutrients (energy, protein, fat, calcium, vitamins A, D, and E, riboflavin, thiamine, and iron) (Keene 1979; Keene, 1985; Kuhnlein et al., 2006; Sinclair, 1953). Calcium, though nutritionally satisfied, was the limiting element amongst all nutrients (Keene, 1979; Keene, 1985). Furthermore, in addition to the required intake of 9.6 MJ (2300 Kcal) of energy per day, hunting activity yielded a surplus of 5.4 MJ/day (1300 Kcal/day) (Keene, 1979; Keene, 1985).

On the whole, a considerable change in diet construct has been observed in Inuit communities. Where diet was once almost entirely reliant on traditional (country) foods, it now consists of a distinguishable mix of traditional and commercial foods and displays a high reliance on non-traditional foods relative to traditional foods (Hopping et al., 2010). In light of this shift to a mixed diet, there has been a consequential increase in the amount of sugary, processed foods (Hopping et al., 2010; Jeppesen and Bjerregaard, 2012; Sharma et al., 2013; Sheehy et al., 2013; Zotor et al., 2012). In particular, fats acquired from game animals have been exchanged for fats that come from processed, store-bought foods, which have notoriously higher amounts of trans-fatty acids (Hopping et al., 2010). Moreover, these processed sources of fat often lack the nutrients such as vitamins A and D that accompany traditional fat sources (Hopping et al., 2010; Kuhnlein et al., 2006). Since both saturated and trans fats have a causative role in

increasing serum LDL-cholesterol concentration (Becker et al., 2004; Freeman and Junge, 2005), this kind of fat intake is inadvisable. As the name implies, LDL cholesterol is low density, which allows more particles to occupy a smaller amount of space. This then contributes to the build-up of plaque and formation of blockages in the arteries, which ultimately increases the risk of heart attack and stroke (American Heart Association, 2012; Freeman and Junge, 2005). In addition to the health complications associated with poorly obtained macronutrients, the lack of micronutrients (fiber, calcium, folate, and vitamins A, C, D, and E) that now exists in Inuit diet puts individuals at greater risk of developing chronic diseases such as cancer and other infectious diseases due to compromised immune function (Hopping et al., 2010; Kuhnlein et al., 2006; Sharma et al., 2013; Zadworny, 2014). The relationship between micronutrients and disease is further highlighted by the fact that there was a relative lack of chronic disease experienced under the prehistoric diet regime in which all micronutrient needs were satisfied (Hopping et al., 2010; Sharma et al., 2013).

Additional complications within the contemporary Inuit diet also stem from increasing portion size. Portion size is a major contributing factor to the obesity epidemic and has in fact increased in all foods over the last few decades (Sheehy et al., 2013). Most notably, the portion sizes of sweetened beverages are particularly large at twice the standard serving size (Sheehy et al., 2013). While an increase in portion size is unhealthy, an increase in market food purchases (as is the case with these beverages) is particularly damaging since gross consumption in turn contributes to an increased portion of energy intake in the overall diet (Sharma et al., 2013). The combination of over-consumption and consumption of nutrient poor foods in the present Inuit diet is worrisome.

In fact, the effects of the overconsumption of energy dense, nutrient poor foods have begun to emerge. The dangerous combination of increased portion size and decreased nutritional value of foods has contributed to an overall increase in the incidence of obesity in Inuit communities (Sharma et al., 2013; Sheehy et al., 2013). In recent years, an increase in the incidence of obesity in Inuit populations, from 23% in 1992 to 37% in 2004, has been recorded (Sharma et al., 2013; Sheehy et al., 2013). Should this trend in diet continue, it is likely that an even greater increase in the incidence of obesity will be observed.

The effects of obesity are significant as obesity is a precursor to further health complications including cancer, cardiovascular disease, stroke, hypertension, dyslipidemia, Type 2 Diabetes Mellitus, joint disease, and several other conditions and opportunistic infections (Sheehy et al., 2013; Zadworny, 2014). This is problematic because the increased incidence of these chronic diseases will undoubtedly be met with decreased productivity, shortened life expectancies, and increased costs of health care (among many other negative consequences). The outcome of such increased prevalence of obesity is a change in the demographic of diseases affecting Inuit populations, as well as a change in the leading causes of death. While Inuit populations were previously protected from atherosclerotic diseases and diabetes by their genetic isolation, this protection has been disappearing as a result of lifestyle changes such as this observed shift towards a less favorable diet (Bjerregaard et al., 2008). For instance, in the Northwest Territories, between 2005 and 2007, the leading causes of death were cancer (including colorectal, breast, prostate, and lung), followed by cardiovascular disease, and then respiratory disease (Zotor et al., 2012).

In addition to the strain on the body system that extra weight provides, increased body weight is also associated with increased incidence of cancer due to the presence of

Type II Diabetes (Zadworny, 2014). Diabetes causes insulin resistance, which results in higher blood insulin concentration as well as failed removal of glucose from the blood. This is detrimental to the cells because insulin is a mitogen, meaning it stimulates mitosis (i.e. cell division). Further, tumor cells require a high level of glucose as an energy source. Thus, in conjunction with a high level of insulin there is increased proliferation and subsequent opportunity for cell transformation to occur (Zadworny, 2014). This systemic pathway is further supported by the increased incidence of diabetes seen since the 1980s in Inuit communities as well as a shift in the type of cancers occurring in these communities (Bjerregaard et al., 2004). "Traditional" Inuit cancers (including nasopharynx and esophageal cancers) have been declining while "modern" cancers such as breast, colon, and cervical cancers that are common to industrialized societies are rising (Bjerregaard et al., 2004; Friborg and Melbye, 2008). From this information, one might conclude that shifting diet towards consumer foods that are more typical of industrialized societies could be to blame for the change in increased suffering from these emerging conditions as well as the incidence of disease.

Though overweight and obesity levels are increasing in many populations around the world, disease in Inuit communities is especially taxing because the geographic remoteness of these communities makes the cost of treating these diseases particularly high (Sharma et al., 2013; Sheehy et al., 2013). Of additional concern is the observation that the altered dietary composition is more prominent among younger generations, which will have serious implications on future directions of diet quality and respective health (Jeppesen and Bjerregaard, 2012). It therefore becomes ever more imperative to shift trends in Inuit diet towards a more positive direction.

Beyond the increased incidence of diet-related chronic disease markers in Inuit communities, socioeconomic status within Inuit communities also plays a significant role in influencing the nutritional adequacy of an individual's diet. Indigenous peoples experience a "disproportionate burden of food insecurity" compared to non-indigenous counterparts in the same country or region (Egeland et al., 2011). In particular, Inuit populations experience the highest reported incidence of food insecurity for indigenous peoples in North America (Egeland et al., 2011). Food insecurity, which is directly related to poverty, is associated with disrupted eating patterns and decreased dietary quality with respect to nutrient composition (Egeland et al., 2011; Huet et al., 2012). This thereby predisposes impoverished groups to compromised health and diet-related chronic diseases (Egeland et al., 2011). The effects of poverty are further compounded by the progression towards a less healthy, market-reliant diet and the fact that market goods are particularly expensive in the Canadian Arctic (Egeland et al., 2011). Specifically, the preservation and transport of fresh fruits and vegetables (among other items) is quite difficult and expensive, meaning that the quality of fruits and vegetables available is substandard (often frozen rather than fresh) and the extra expenses in providing them are translated into increased prices (Sheehy et al., 2013). As such, consumption of these imported foods such as fruits and vegetables is highest among the wealthy (Jeppesen and Bjerregaard, 2012). Households of lower socioeconomic status on the other hand, consume fewer vegetables and greater amounts of cheaper, high sugar foods (Huet et al., 2012).

Because market foods are expensive and nutritionally inadequate, one might wonder how the Inuit diet could have ever evolved to incorporate less traditional foods and more market foods. This is partly due to the fact that it has become increasingly costly to obtain traditional foods.

The development of a wage economy has left households without hunters and without time to devote to hunting activities. The presence of a male head of household as well as access to an income both increase the proportion of traditional foods found in the diet (Duhaime et al., 2002), thereby decreasing the prevalence of food insecurity and poor nutrition. In fact, it was reported that the chance of having a high vegetable intake is doubled by the presence of at least one employed adult in a household (Hopping et al., 2010; Jeppesen and Bjerregaard, 2012). Further, the cost of hunting equipment is also prohibitively high (Beaumier and Ford, 2010; Huet et al., 2012; Sheehy et al., 2013). In fact, one strategy that has emerged to offset the high cost of hunting is to sell some of the country foods acquired in the practice (Beaumier and Ford, 2010). In addition to the logistics of hunting, Inuit have also experienced a reduction in animal population and a change in migration patterns as a result of climate change among several other factors (Beaumier and Ford, 2010; Sheehy et al., 2013). The challenge of such scarcity of game in conjunction with the increased cost of hunting has led to a decline in the communal food sharing networks that were once present in Inuit communities (Beaumier and Ford, 2010; Sheehy et al., 2013). Overall, it is the combination of reliance on expensive market foods, the purchase of relatively less expensive but less nutritionally valuable items within markets, and increased costs of hunting that has left individuals of low socioeconomic status at a great disadvantage when it comes to achieving the recommended nutrient intakes.

There are several factors that contribute to the relative nutritional status of Inuit populations. The largest influencing factor is the shift from an entirely country food diet to a mixed diet that entails a heavy reliance on high energy but non-nutrient dense foods. However, within the present diet, socioeconomic status has a large influence on ingested nutrients, as it determines what resources an individual will be able to access. Beyond to restrictions on hunting (due to its high cost and the need to participate in the wage economy) and purchasing country foods, those of lower socioeconomic status are burdened by the need to purchase expensive market foods. Thus, in an attempt to budget, low socioeconomic status individuals are likely to purchase relatively cheaper foods in markets, which tend to be of poor nutritional value.

Given the industrial development that is spreading across the globe, it seems likely that markets will retain their presence in Inuit communities. As such, governments should target the provision of better quality foods such as fiber-rich foods such as fruits and vegetables to these stores (Jeppesen and Bjerregaard, 2012; Sheehy et al., 2013). While there has been some acknowledgement of this conundrum at the level of the Canadian government in the form of attempted subsidy programs to provide essential goods, these programs have been found to be ineffective. (Spiegelaar and Tsuji, 2013). Intake of fruits and vegetables, for example, remains an uncommon part of diet in these Inuit communities (Spiegelaar and Tsuji, 2013). As a result, there has been work dedicated to the overhaul of programs such as the Food Mail Program, which partially subsidizes the transportation of produce and other essential goods to northern communities. In fact, the Food Mail Program has been replaced with Nutrition North, which subsidizes food suppliers rather than food transporters (Spiegelaar and Tsuji, 2013). The importance of this work is twofold: first, these programs are important in combating food insecurity, a second, the increased provision of fiber (in the form of fruits and vegetables) can help to protect against obesity and colon cancer because it reduces constipation (Becker et al., 2004).

Similar to recommendations for the remainder of Canada

as well as the USA and other countries, it is recommended that the intake of sugar-sweetened beverages be reduced as they are instrumental in weight gain and provide little nutritional value (Sheehy et al., 2013; Zotor et al., 2012). Furthermore, individuals can reduce their intake of saturated fats in exchange for mono- and poly-unsaturated fatty acids by replacing butter and margarine, which are frequently used in sauces, with vegetable oils (Jeppesen and Bjerregard, 2012). One interesting suggestion found among the literature to improve diet quality exploits the popularity of soups and recommends consuming soup as a pre-load before meals to reduce total energy intake. This is expected to be instrumental because soup has a high satiety value and has low energy density (i.e. few calories). Therefore, it is a useful tool to reduce portion size (Sheehy et al., 2013). Finally, additional nutritional education should also be provided to Inuit communities (possibly in the form of leaflets) to help them make informed, wiser decisions about their consumption. For example, Zotor et al. (2012) suggest educating both retailers and home food preparers about the negative health implications of over-consumption of nutrient poor foods as a means to reduce consumption of nutrient-poor, energy-dense foods.

One limitation of Inuit nutrition studies includes the means by which food intakes are acquired. Researchers often rely on the use of food-frequency questionnaires (or other equivalent interview techniques with different names) to determine intake, which is dependent on proper recall and comprehension by surveyed individuals (Sharma et al., 2010; Sharma et al., 2013; Zotor et al., 2012). One study specifically mentioned under-reporting of intakes by individuals as a complication (Johnson-Down and Egeland 2012). Another limitation encountered was poor transparency in the comparison of prehistoric and contemporary diets. Several studies investigated contemporary diets and then qualitatively discussed changes in portion size or the prevalence of market foods consumed but neglected to specifically quantify those changes. Some studies also qualified the benefits of consuming traditional foods by comparing the adequacies of different diets from different individuals in the same generation rather than comparing the overall diet of the current generation to that of the past (Hopping et al., 2010; Jeppesen and Bjerregaard, 2012; Sharma et al., 2013; Sheehy et al., 2013; Zotor et al., 2012). Quantitative analysis of changes in diet with respect to energy and nutrient intake will help to further support the trends experienced and could prove to be an interesting investigation for future research.

Further research in this area could also be conducted to address changes in physical activity. The World Health Organization cites physical inactivity as the "fourth leading risk factor for global mortality" (WHO, 2010). It also addresses the fact that physical inactivity is globally on the rise and that such inactivity has "major implications for the prevalence of non-communicable diseases" including those discussed in this review (WHO, 2010). In light of the decreased hunting activity discussed, change in physical activity could be assessed in terms of its implications on Inuit health. It would be interesting to assess whether the recommendations for energy and nutrient intakes change as a result of changed physical activity levels. If this is the case, it would also be important to reassess the quality of current intakes. Finally, additional studies could also be developed to investigate the implementation and effectiveness of education and nutritional intake programs. Specifically, programs that test the merit of various diet plans will need to address compliance to the diets themselves.

Ultimately, there is great need in Inuit communities for a new dietary transition geared towards consumption of less energy dense and more nutrient rich foods. Current

trends in the Inuit diet parallel an increase in obesity and diet-related chronic diseases that are significantly different than traditional diseases. While socioeconomic dynamics remain a challenge, it is imperative to continue work to tackle the dietary transition and its associated health complications.

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