PhD Thesis

Traditional food in Greenland: relation to dietary recommendations, biomarkers and glucose intolerance

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Overview of papers

**Paper 1** Consumption of traditional food and adherence to nutrition recommendations in Greenland
Charlotte Jeppesen and Peter Bjerregaard.
*In review.*

**Paper 2** Assessment of consumption of marine food in Greenland by a food frequency questionnaire and biomarkers
Charlotte Jeppesen, Marit Eika Jørgensen, and Peter Bjerregaard
*Int J Circumpolar Health 2012, 71: 18361 - http://dx.doi.org/10.3402/ijch.v71i0.1836*

**Paper 3** Dietary patterns in Greenland and their relationship with type 2 diabetes and glucose intolerance.
Charlotte Jeppesen, Peter Bjerregaard, and Marit Eika Jørgensen
*In review.*
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Photos by Cecilia Petrine Pedersen.

**Abbreviations**
IFG: impaired fasting glucose
IGT: impaired glucose tolerance
T2DM: type 2 diabetes
FA: fatty acid
FFQ: food frequency questionnaire
DHA: docosahexaenoic acid
EPA: eicosapentaenoic acid
MeHg: methyl mercury
HOMA: homeostatic model assessment index
HOMA-IR: insulin resistance
HOMA-β: beta-cell function
PREFACE

Data for this study are based on the population study conducted in Greenland in the years from 2005–10. The thesis was carried out from January 2009 to December 2011 at the National Institute of Public Health (NIPH) in Copenhagen, Denmark.

I wish to thank my two supervisors, Peter Bjerregaard and Marit Eika Jørgensen, who have both supported me and given me constructive criticism. My sincere gratitude goes to Carol Bang-Christensen and Beth McAuley for editing the language of the final thesis and some of the papers.

I also want to thank my colleagues at the Centre of Health Research in Greenland: Christina, Cecilia and Camilla and to Susanne who helped with the lay-out of papers and thesis. In particular I want to thank Inger, who shared an office with me during most of this work, for her constant support and for keeping the atmosphere positive around me. My appreciation to my former colleague at NIPH, Anni Nielsen, for sharing her experiences with me and advising me through difficult times. In Greenland several people have been helpful when I needed clarifications and specific information: Tine Pars (PhD), Ingelise Olesen (research assistant) and Anita Johansen (Adviser) from the Nutrition Board of Greenland and PAARIISA (Agency for Health and Prevention).

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Finally, my deepest thanks to my closest family and Jens for their patience through the many evenings and weekends that were filled with lots of work.
INTRODUCTION
Greenland is the world’s largest island. Located in the Arctic and with a population of 56,615 people, it is the least densely populated country in the world (1). The island is surrounded by water; and towns and villages are situated along the coast, with the population being concentrated along the west coast. Naturally, Inuit have always made use of the ocean and its animals as a source of food. Early research in Greenland found that Inuit lived almost entirely of marine mammals and fish. The diet was based on raw, boiled or dried meat, and blubber from seals (mostly Greenland seal, bearded seal and ringed seal) and whales (2). Traditional diets also included dried meat and skin from whales, meat and fat from walrus, polar bear and sea birds, and a number of marine and freshwater fish. Flowers, roots, berries and leaves were a supplement to the daily diet but with seasonal variation. Dietary changes started to progress after the 1940s in time with a rapid population growth. Imported foods, mainly from Denmark, initiated a change in dietary habits. The morbidity pattern changed parallel to these dietary changes: the prevalence of infectious diseases decreased and the prevalence of type 2 diabetes started to increase (3). According to the World Health Organization, 346 million people worldwide have diabetes and more than 80% of diabetes deaths occur in low- and middle-income countries (4). Diabetes and pre-diabetic stages were also highly prevalent in our Inuit study population. Nine percent were diagnosed with type 2 diabetes and a further 19% were diagnosed with impaired fasting glucose (5). There is no doubt that traditional food plays an important role for Inuit in Greenland for social, historical, economical and in some cases also nutritional reasons. Nevertheless, there is a rising need to evaluate traditional food from a public health nutrition point of view and for that researchers need reliable methods to assess dietary intake. This thesis will evaluate traditional food in relation to the existing nutrition recommendations, in relation to measurements of dietary intake and in relation to one of the largest public health concerns in Greenland: glucose intolerance.
OBJECTIVES

The overall objective was:

- To study the consumption of traditional food in the modern Inuit diet and the association to biomarkers of marine food intake, prevalence of glucose intolerance and adherence to dietary recommendations.

To do this, the overall objective was broken into three specific objectives:

I: To describe modern Inuit consumption of traditional food and adherence to the recommended macronutrients distribution range. (Paper 1)

II: To evaluate the agreement and assess the association between biomarkers and food frequency questionnaire data. (Paper 2)

III: To analyse the association between dietary patterns and glucose intolerance. (Paper 3)
BACKGROUND

Dietary assessment in Greenland.

To study the relation between dietary intake and disease outcomes, which is usually the aim of many large epidemiological studies, it is important to use an appropriate method; however, many other aspects play a role in the choice of dietary assessment such as economical costs, time spent on data collection, and the nuisance for the participant when data are collected. This is why dietary assessment in large epidemiological studies is very often done by food frequency questionnaire (FFQ). The FFQ can assess the usual dietary intake over a long period of time. FFQ is non-invasive for the respondent and can be conducted either as an interviewer-guided questionnaire or as a self-administered questionnaire. Many studies include estimation of the typical portion size for each food to estimate consumed amounts, although a large within-person variation exists in portion size for most food items (6). This increased variation can decrease the validity of the questionnaire. As an alternative to questionnaire data, biomarkers can provide a surrogate measurement of past dietary intake. One of the disadvantages of the FFQ is obviously recall bias and respondent memory lapse. Another known bias is the respondent bias in the form of under- and over-reporting actual intakes. It has been shown that obese individuals and women in particular have a stronger tendency to under-report (6). But overall the FFQ is suitable for larger groups to measure their usual intake of foods and food groups.

Dietary assessment can also be conducted with the use of biomarkers. Biomarkers are especially useful when food composition tables are inaccurate or have many missing values. In the study of Arctic diets, a few biomarkers can be considered to be of special value since they represent dietary components typical for the Inuit diet. Traditional marine diets have a high content of long-chain polyunsaturated fatty acids (PUFA), especially eicosapentaenoic acid (EPA) and docohexaenoic acid (DHA). It is commonly understood that the dietary fatty acid (FA) intake will be reflected in the adipose tissue, in the plasma and in the membranes of erythrocytes. The erythrocyte membrane FA profile can be used as an indicator of the dietary intake of FA, although it has been found that EPA and DHA have differences in their metabolic rates (7). Sun et al. (8) found that measurements of erythrocyte membrane FA were stronger correlated to actual intake as measured by FFQ data when compared to plasma measurements of FA. Plasma FA are; however, are less expensive to measure than
erythrocyte membrane FA. A study conducted among Inuit in Nunavik found that marine mammal fat was stronger associated with erythrocyte content of PUFA better than marine mammal meat and total fish intake (9). Others have compared the intake of omega-3 and omega-6 polyunsaturated FA (PUFA) assessed by a FFQ with PUFA measured in erythrocyte membranes; overall it seems that erythrocyte membranes can provide good biomarkers of PUFA intake (10). Fatty acids are not the only available biomarkers for the consumption of traditional food. A traditional diet also exposes the Inuit to various kinds of environmental pollutants. For example, mercury accumulates in animal tissue in the form of methyl-mercury (MeHg), which is highly toxic. Human exposure to MeHg in Greenland is mainly through consumption of marine mammals, because mercury accumulates in the top predators of the food chain. Seal, which is a top predator mammal, is also one of the most commonly eaten traditional foods in Greenland; one study has shown that seal liver has a particularly high concentration of mercury (11). Hence, mercury may be useful as a biomarker of intake of the sea mammal content of the traditional diet. Fontaine et al. studied the mercury concentration in blood among Inuit residing in Nunavik, Quebec, and found that mercury levels were dependent on age and on the consumption of marine mammal meat(12). Mercury and erythrocyte DHA have been shown to be possible biomarkers of fish and seafood intake in a study in Norway (9).

**Nutrition transition**

Today, the diet of Greenland is still changing like in many other Arctic regions (13). Imported food contributes more and more to the Inuit diet. Younger people eat less traditional food than elder generations and on average traditional food contributes to approximately 20% of the dietary intake(14). The proportion of people who eat traditional food on a weekly basis decreased between 1993 and 2010, according to our previous surveys shown in Table 1.
Table 1. Difference in the amount of people in Greenland who consumed various traditional foods at least once per week in 1993 and in 2005–09. (1993: N=1,356–71; 2005–09: N=2,525–34). The model is adjusted for age and sex.

<table>
<thead>
<tr>
<th>Food item</th>
<th>1993 (95% CI)</th>
<th>2005-09 (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seal</td>
<td>63% (61; 66)</td>
<td>37% (35; 39)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Whale</td>
<td>28% (25; 30)</td>
<td>27% (25; 28)</td>
<td>0.6</td>
</tr>
<tr>
<td>Fish</td>
<td>65% (63; 68)</td>
<td>58% (57; 60)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Reindeer</td>
<td>11% (9; 13)</td>
<td>21% (20; 22)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Game birds</td>
<td>42% (40; 45)</td>
<td>33% (31; 35)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Modified and updated from (14)

Dietary and other lifestyle changes have occurred parallel to demographic and cultural changes in the Arctic region. The lifestyle of the Inuit community is becoming more sedentary and the technological development in the country brings new traditions and social values to the population. As a consequence of rapid change in lifestyle, the prevalence of obesity has increased dramatically. In Greenland more than half of the Inuit population is overweight or obese when using body mass index (15), the most widespread measurement of obesity, and this tendency is seen all over the Arctic regions (16). Research has shown that obesity is by far one of the largest risk factors for development of lifestyle diseases such as diabetes (17-20). The composition of one’s diet has been proven to influence the risk of developing type 2 diabetes (T2DM) and obesity (17). During the last 20 years, T2DM and impaired glucose tolerance (IGT) have increased in Greenland (21). Hence, there is a need to study associations with and effects of diet in relation to T2DM in this population.

Public health nutrition

A part of public health nutrition is to develop recommendations and guidelines for the average population outlining a diet that will provide energy and nutrients for optimal growth, development, function and health during the entire life cycle (15). Function and health means prevention of disease, e.g. lifestyle diseases such as diabetes. As the diet becomes more and more western in its foods and eating patterns, there is an increasing need to assess the adherence to dietary recommendations in Greenland. Nutrition recommendations can be broken into two major components: 1) the
evidence based recommendation targeted e.g. policy makers, researchers and the
general health system. 2) the guidance for the general population.

1) Most countries have dietary guidelines expressed in scientific terms, and these
include recommendations for intakes of nutrients and food components. Nutrition
recommendations include recommended dietary allowances (RDAs), reference nutrient
intakes (RNIs) and dietary reference values (DRVs). However, such recommendations
are difficult to apply in a daily setting and commonly misunderstood by both
nutritionists and the general public. The general population has no knowledge of their
ture nutrient requirements, and their information about the actual nutrient content of
the foods they eat is incomplete. Furthermore, not many countries have complete
nutrient tables available that include all foods available to the consumers.

2) Food-based dietary guidelines (FBDG) are a translation of the nutrition
recommendations. Their purpose is to provide nutrition education and dietary
guidance for the general public by short and clear messages. These messages may
include recommendations on intake of energy and nutrients or consumption of specific
foods or food groups. FBDG may include food choices, amounts and frequency of
consumption and should guide consumers on what to eat and help them make healthy
dietary choices.

A part of nutrition recommendations is the recommended macronutrient distribution
range (RMDR). There are several ways to evaluate dietary intake. The following
studies will use adherence to FBDG to derive dietary patterns and secondly, the RMDR
to evaluate dietary composition. The dietary recommendations from the Nordic
Nutrition Recommendations are given in table 2. Dietary recommendations and the
recommended macronutrient distribution range were in a Greenland context based on
Nordic Nutrition Recommendations of 2004 (22). Arctic research that has evaluated
dietary composition in relation to these recommendations has mainly focused on
single nutrients at the micronutrient level. Among Inuit in Nunavut, the average diet
provided inadequate amounts of dietary fibre and micronutrients like calcium, folate
and vitamins A, D and E (23). A study conducted in Alaska also found the intake of
nutrients like calcium and fibre to be inadequate among Native people (24). In
Greenland, researchers collected samples and compared the composition of local diets
in two studies that were set 50 years apart. The second study found decreased dietary intakes of vitamin C, folate, calcium, vitamin A and vitamin E, with intakes of all of these nutrients being below the recommended level. Overall consumption of traditional food had also decreased over the 50 years between the two sample collections (2).

Table 2. The recommendations set by Nordic Nutrition Recommendations (2004).

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrate</td>
<td>50–60 E%</td>
</tr>
<tr>
<td>Fibre</td>
<td>Between 25–35 g/day</td>
</tr>
<tr>
<td>Refined sugar</td>
<td>Maximum 10 E%</td>
</tr>
<tr>
<td>Protein</td>
<td>10–20 E%</td>
</tr>
<tr>
<td>Total fat</td>
<td>25-35 E%</td>
</tr>
<tr>
<td>Saturated fat</td>
<td>Maximum 10 E%</td>
</tr>
<tr>
<td>Monounsaturated fat</td>
<td>10–15 E%</td>
</tr>
<tr>
<td>Polyunsaturated fat</td>
<td>5–10 E%</td>
</tr>
</tbody>
</table>


Nutrition recommendations can be used in relation with dietary pattern analyses. Dietary patterns can be derived mainly in two different ways: an a priori (normative) approach, and a posterior (data-driven) approach. The normative approach is a hypothesis-based approach where the patterns are defined based on either scores or an index. Examples include the "healthy eating index" or dietary quality scores (25;26). Selected aspects of the diet (e.g., sugar, fibre, total fat, etc.) are dichotomized into criteria with predefined cut-points, and each participant gets points in each category. The scores can also be placed into quartiles or quintiles in order to group the participants, or they can be treated with a continuous approach where weights can be assigned to each score. The data-driven approach usually uses statistical methods such as principal component analysis, factor analysis, cluster analysis or a combination of these. The dietary patterns are derived from statistical data reduction, mostly done by factor analyses, followed by clustering the factors together in patterns using cluster analyses. There are advantages and disadvantages to both methods (27). The common advantage of both of these two methods is the fact that no single nutrients are studied; instead, the diet is considered as a whole.
component, taking into account the interactions between foods and nutrients that occurs in real life. The normative approach has the advantage that the groups are not specific to the data set from which they were produced, while the data-driven approach produces patterns that are applicable only to that specific data set and may not be applicable to a realistic setting. On the other hand, the researcher could use the data-driven approach to explore new and not-yet-identified dietary patterns that could be of interest in a clinical setting. The normative approach is highly suitable for public health purposes and in places where research needs to form a basis for the development of guidelines. Nutrition epidemiology has moved towards studying dietary patterns instead of single components in relation to disease outcomes such as diabetes.

**Type 2 diabetes**

T2DM is defined by the level of hyperglycemia (28). Two primary defects are characteristic for T2DM: insulin resistance, where tissue has become less sensitive to insulin; and impaired beta-cell function, where insulin release is delayed or inadequate. Insulin deficiency can be a primary effect or can be progressed by aging. Further, it can be a result of a longer period of exceeded insulin production that leads to beta-cell exhaustion (29). Insulin secretion and insulin resistance can be measured by the HOMA-index (homeostatic assessment model) and are important risk factors for the development of pre-diabetes and T2DM. Alternatively, increased fasting insulin can be used as a marker of hyperinsulinemia secondary to insulin resistance. Pre-diabetic stages develop when glucose levels increase into impaired fasting glucose (IFG) or impaired glucose tolerance (IGT), or a combination of these two stages. Several other metabolic risk factors appear prior to the development of pre-diabetes and T2DM. There have been studies of dietary composition in relation to T2DM; in these studies, total fat in the diet and especially saturated fat were found to be associated with the development of T2DM (30). The fat profile affected insulin sensitivity and blood pressure (31) while a study found that substitution of saturated fat by polyunsaturated fat improved insulin sensitivity – and, in combination with weight loss and increased physical activity, it decreased the risk of T2DM development among participants with glucose intolerance (32). Added sugar in sugar-sweetened beverages has been shown to increase the risk of type 2 diabetes (33). Fibre has been
shown to be important in relation to colon cancer (34), cardiovascular disease (35) and type 2 diabetes (36;37). By contrast, whole-grain products in the diet decreased the risk of T2DM development, likely due to their content of cereal fibre (27;38;39). Research studying the association between traditional food and diabetes has up until now shown opposing results. Former research conducted in Greenland found that fasting blood glucose was positively associated with consumption of seal (40), while another study found that daily consumption of seal and salmon was associated with a lower prevalence of IGT and T2DM among Alaskan Natives (41). The traditional diet is high in N3 FA due to a high content of marine mammals and fish. The studies of the benefits of N3 FA and clinical insulin outcomes are contradictory: a large review including both human and animal models concluded that N3 FA had clinical significance in the prevention and reversal of insulin resistance (42). On the other hand, moderate fish oil supplementation showed no effect on insulin sensitivity, insulin secretion or β-cell function in healthy individuals (43); and insulin sensitivity was not influenced by increasing N3 FA in the diet (44).

Dietary pattern analyses have been used in studying the diet in relation to diabetes as well. A dietary pattern characterized by red and processed meat, French fries, high-fat dairy products, refined grains and sweets resulted in a higher risk of T2DM (38). A similar dietary pattern that also included red and processed meat and refined grains was associated with an 18% greater risk for T2DM(39;39). In an Arctic setting, Eilat-Adar showed that a traditional dietary pattern among Alaskan Eskimos was associated with a more favourable cardiovascular profile(45).

**MATERIAL AND METHODS**

**Data collection**
The Inuit Health in Transition Study (IHT) is an international collaborative study among several countries: Greenland, Canada and the United States. The IHT study aimed in particular to assess risk factors of cardiovascular disease and diabetes among the people living in Alaska, Nunavut, Nunavik and Greenland. Greenland has a history of population-based health studies that goes back to 1993, when the first large cross-sectional survey of health including diet took place.
**Places of data collection**

In 2005 the survey started on the west coast of Greenland and collected data from Upernavik along with the villages Kullorsuaq and Innaarsuit in the North; as well as Qaqortog, the medium-sized town of Narsaq and the villages Eqalugaarsuit, Narsarmiit and Aappilattoq in the South. Also included in this sample were Nuuk and Maniitsoq as larger towns in relation to the villages of Atammik and Napasoq. In 2008, data from the east coast were added, coming mainly from the city of Tasiilaq together with the villages Kuummiut and Tiniteqilaq. Recently, in 2010, additional data from Qaanaaq along with Siorapaluk, Qeqertat and Moriussaq were included in the sample. See Figure 1.

**Study population**

All participants were selected through a random sample of adults (18+) residing in Greenland. The country was divided into 12 regions in order to cover all communities. From each region a number of villages and towns were chosen to be included in the study. In towns, a random sample of 11–22% of the population was drawn from the central person register (CPR). In villages, all adult inhabitants were invited to participate. The final sample selected from the CPR consisted of 5,009 people, both Inuit and Danes. Interviews were conducted in Greenlandic or Danish according to the wishes of each participant. Clinical information was available for 99% of Inuit participants. Questionnaires were translated from Danish into Greenlandic and then translated back into Danish in order to validate the translation. The final sample included in the analyses was only of Inuit ethnicity. We operated with ethnicity according to two definitions: (1) Ethnicity was determined at enrolment based on the primary language of the participant and on self-identification. Only one ethnicity was
allowed for each participant. (2) For analytical purposes, we also operated with ethnicity according to the ethnicity of the parents and grandparents of each participant, based on the participant’s own judgment. When Inuit ethnicity was identified from definition 1 we categorized the participant into two possible categories: partly Inuit or fully Inuit. If one to three of the four grandparents were of Inuit heritage, the participant was defined as partly Inuit. If all four grandparents were Inuit, the participant was defined as fully Inuit.

**Questionnaire data and food frequency questionnaire**

Two questionnaires were used to obtain information from the participants: a self-administered questionnaire and one for the interviews.

Alcohol consumption was the only data from the self-administered questionnaire that was used in this study; subjects were grouped by this data into daily drinkers, weekly drinkers, monthly drinkers and abstainers. Information about smoking, diet, ethnicity, demography, and physical activity was obtained from personal interviews. Smoking data were used to characterize respondents as never smoking, previous smoker or current smoker. We measured physical activity by a modified version of the International Physical Activity Questionnaire (IPAQ) (long version) (46). From this questionnaire we estimated the number of minutes spent weekly on physical activity. Also included in the questionnaire data was a FFQ with 68 kinds of food listed, including 25 traditional foods and 43 imported foods and beverages. Traditional food on the list included sea mammals, terrestrial animals, game birds and fish. Sea mammals included seal, whales, walrus and various products from these animals like muktuk or dried meat. Terrestrial animals included caribou and musk ox as well as dried meat from these animals. Various fish species were recorded, including cod, Greenland halibut, ammassat, trout and salmon; as well as various sea foods, such as mussels, shrimp and crab. Game birds included guillemot and eider duck as well as eggs from these birds. In 2008, when data collection was expanded to include Tasiilaq, we included polar bear as a food item in the FFQ. Frequency of consumption, estimated portion sizes and seasonal variation were also reported. Additionally, for traditional foods we recorded seasonal length and took that into consideration when calculating their yearly consumption. The interviewer recorded all foods and the frequency of their consumption (daily, weekly, monthly or yearly), and the participant
estimated a portion size from photos showing four different portion sizes. From the FFQ data, a measurement of grams per day/month/year was calculated for each food item and additionally for the main food groups: imported meat; traditional food (separated into subgroups: marine mammals, fish, terrestrial animals, game birds); dairy products; bread and cereals; fruit; vegetables; candy and cake (sugar-dense products); and junk food (burgers, pizza, hotdogs, salted snacks). Marine mammals included seal meat; dried seal; seal blubber; seal inner organs; whale meat (including beluga, narwhal and other whales); dried whale meat; whale blubber; muktuk; and walrus.

**Blood samples**

In this study we used blood samples for the purpose of biomarkers and for glucose and insulin measurements in order to estimate insulin resistance, beta-cell function, pre-diabetes and diabetes. Blood samples were drawn from fasting individuals, defined as having spent a minimum of eight hours without consuming any liquids or food. Participants underwent a 2h oral glucose tolerance test (OGTT). For the 2h OGTT, participants received 246.5 ml (333.3 mg/ml) glucose monohydrate, equivalent to 75 g of glucose. Blood was drawn from the cubital vein. Plasma was separated and frozen at 20°C and transported to one central laboratory for the measurement of plasma glucose. Plasma glucose was analysed using Hexokinase/G6P-DH-Determination on a Hitachi 912 System. Insulin measures were analysed by two-site fluoroenzymometric assay for quantification of intact insulin in human serum (Wallac Auto Delfi). Both glucose and insulin were analysed at the laboratory at Steno Diabetes Centre, Gentofte, Denmark.

From blood samples we also obtained data for analyses if dietary biomarkers. However, because of logistical damage during the transportation from Greenland to Denmark, the blood samples from the East coast could not be used. Furthermore, when data was analysed for this thesis, the biomarkers from the blood samples from Qaanaaq were not yet analysed. Hence, biomarker data were obtained from 3,035 participants for mercury and 2,449 participants for FA profiles measured in erythrocyte membranes. The measurement of FA in erythrocyte membranes was performed at the Lipid Research Centre, Centre Hospitalier Université Laval, Canada.
A total of 40 FA were measured, including N3 and N6 FA as well as trans-FA. Mercury was analysed at Centre de Toxicologie, Institut National de Santé Publique, Quebec, Canada. The composition of phospholipids of erythrocyte membranes was measured after total lipid extraction with chloroform/methanol mixture, phospholipid separation by thin layer chromatography and methylation of FA, followed by capillary GLC using a DB-23 column in a HP-Packard GC chromatograph. Whole blood mercury was analysed at Centre de Toxicologie, Institut National de Santé Public, Québec, Canada by Inductively coupled mass spectrometry (ICP-MS). Detection limit: Mercury 0.5 mmol/l.

**Anthropometry**

Weight and height were measured while the participants were without shoes and wearing light clothing. Waist circumference was measured on standing participants midway between the rib and the iliac crest. Body mass index was used as a measurement of overall obesity and was calculated from the height and weight of each participant (BMI=height in m²/weight in kg).

**Definitions**

*Glucose intolerance*

To diagnose pre-diabetes and T2DM, WHO has set the following standards based on an OGTT (Table 3). These definitions were used in the following analyses.

Table 3 shows the WHO standards for diagnosis of pre-diabetes and T2DM based on an oral glucose tolerance test (28).

<table>
<thead>
<tr>
<th>WHO Diagnostic criteria</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IFG</strong></td>
<td>Fasting plasma glucose from 6.1 to 6.9 mmol/L and 2h plasma glucose &lt;7.8 mmol/L</td>
</tr>
<tr>
<td><strong>IGT</strong></td>
<td>Fasting plasma glucose &lt;7.0 mmol/L and 2h plasma glucose ≥7.8 mmol/L and &lt;11.1 mmol/L.</td>
</tr>
<tr>
<td><strong>T2DM</strong></td>
<td>Fasting plasma glucose ≥7.0 mmol/L or 2h plasma glucose ≥11.1 mmol/L</td>
</tr>
</tbody>
</table>

*Insulin resistance and insulin secretion*

Insulin resistance and insulin secretion (beta-cell function) were calculated using the following equations in the homeostatic model assessment index (HOMA).
HOMA-IR was used as a measure of insulin resistance and was calculated using the following formula:

\[
HOMA-IR = \frac{\text{fasting insulin (pmol/L)} \times \text{fasting plasma glucose (mmol/L)}}{22.5}
\]

HOMA-\(\beta\) was used as a measure of beta-cell function and was calculated using the formula:

\[
HOMA-\beta = 20 \times \frac{\text{fasting insulin (pmol/L)}}{\text{fasting plasma glucose (mmol/L)}} - 3.5
\]

Throughout this study, participants with known diabetes were excluded from the analyses.

**Data analyses and statistical analyses**

For each food item we calculated the energy content (kJ); macronutrients (carbohydrates, fat and protein); FA (saturated fat [SFA], monounsaturated fat [MUFA], polyunsaturated fat [PUFA], eicosapentaenoic acid [EPA], docosahexaenoic acid [DHA], N3 FA); and mercury. These were calculated using nutrient tables with Arctic references and with Greenlandic data where possible, but for FA Canadian references were used (47-49). For imported foods, Danish nutrient tables were used (50). The intake of FA from FFQ was calculated and converted into a percentage of total fat intake. For total N3 FA, we used the total N3 FA value in the nutrient databases, which also included the sum of all detectable N3 FA. This corresponded to the total detectable N3 FA in the erythrocyte membrane. The marine mammal variable was split into fat and lean meat variables, since biomarkers bind to different compositions in the animal: marine mammal meat (g/d) and marine mammal fat (g/d). All statistical analyses were performed with IBM SPSS ver. 19. Several exclusion criteria were used in each paper, with common exclusion criteria for all three studies being ethnicity (according to definition 1) and unrealistic energy intake. Energy intake was used as a criterion because it was the only nutrient that we could develop limits for in order to categorize individuals with an implausible intake. In traditional epidemiology, limits are set by comparing a calculated basal metabolic rate (BMR) based on sex, age and body weight. Energy intakes below 1.2 times the BMR and intakes above 4,000 kcal/day (approximately 16,800 kJ) are excluded (51). In this study the following participants were kept for analysis: Male participants were included if their energy intake was in the range of 3,350–17,000 kJ/day, and women
in the range of 2,100–15,000 kJ/day. Approximately 10% of the study population was excluded based on unrealistic energy intakes calculated from the FFQ. The different exclusion criteria for each study can be seen in Table 4 in result section.

**Paper 1**

This paper assessed the mean intakes of energy (kJ/d), macronutrients (g/d) and fibre (g/d); the energy contribution from traditional food and imported meat (E%); marine mammal intake (E%); and the energy percentage taken from refined sugar (E%). To study the dietary composition in relation to increasing traditional food intake we calculated the energy percentage of traditional food and divided this variable into quartiles. We tested the difference between mean intakes of the above nutrients between quartiles 1 to 4 of traditional food using the general linear model (GLM) with adjustments for sex and age. We described the food source of macronutrients and other selected nutrients by calculating the percentage gained from each food item and assessing the top five contributing food items. To assess the proportion of participants who complied with RMDR as well as the proportion that consumed above and below the recommended amounts, we divided the participants according to the limits of RMDR and weighted them according to age and region to get a realistic distribution of the study population according to the composition of the Greenlandic population.

**Paper 2**

All descriptive analyses were reported in means with SD values. This study had the disadvantage that we had missing values for many FA. A total of 2,224 individuals had valid data for FA. For mercury we had missing values for 56 participants after the exclusion of non-Inuit and those with unrealistic energy intakes. We included the sex (male or female) and smoking status (non-smokers, active smokers or former smokers) of all participants. Age was entered as continuous variable. We also calculated the intake of grams of seal gram/day, grams of whale/day and grams of fish/day from the food frequency data and included these variables in the model to assess which variable was associated to the biomarkers best. Means were reported with standard deviation and all dietary variables were log-transformed before the analyses and transformed back by $10^x$ before reporting. Categorical variables (smoking and alcohol consumption) were reported in percentages.
**Linear associations**

By Pearson correlation adjusted for age we assessed the association between biomarkers and FFQ. For the further analyses all dietary variables were log transformed before analyses and transformed back by $10^x$ before reporting.

**Agreement**

In 1986, Bland and Altman introduced their plots for measuring agreement between two methods (52). The plot depicts the mean difference between the two methods as a function of the average of the two methods (x-axis). Furthermore, a fitted line for the observations illustrates the hypothesis: $y=x$. If the two methods are equal (agrees) the observations will be around the mean difference = 0, which is a horizontal line in the plot and the fitted line will lie closely to the mean difference=0. The method is used in this study because the BA plots give a good visual indication of the agreement. As an important feature in the BA plot are the limits of agreement (LOA). For each Bland Altman plot the limits of agreement (LOA) were calculated as $\text{mean}_{(\text{difference})} \pm 1.96*\text{standard deviation}_{(\text{difference})}$ with the assumption of normal distribution. Within LOA, one can assume that any new observation added to the study population would be within these limits by a 95% chance. In this study the method will be used as well to measure agreement between measured biomarkers and calculated intakes from FFQ, nonetheless, with the limitation that biomarkers and calculated FFQ values will never be exactly the same. Both FFQ variables and biomarker variables were log transformed to achieve normal distribution, and this is in accordance with the recommendations of Bland&Altman, when the scatter becomes wider with increasing intakes (trumpet-shaped scatter) (53). Bland Altman plots were produced in STATA ver. 11.

**Association between marine foods and biomarkers**

Using multiple regressions with forced entry the associations were studied between frequency of marine food intake vs. biomarkers and estimated quantity vs. biomarkers we made regression models with erythrocyte membrane EPA, DHA, N3 FAs, and whole blood mercury as dependent outcomes. All four biomarkers were tested in relation to frequency of seal-, whale-, and fish consumption (meals/month) and in relation to estimated amount of seal, whale and fish consumed (gram/day). The analyses were
adjusted for age, total energy intake (kJ/day), smoking (non-smoker vs. former smoker or current smoker), alcohol intake (abstainers vs. drinking).

**Paper 3**

**Dietary patterns**

We constructed dietary patterns from an a priori (normative) approach by operating the ten pieces of dietary advice given by the Greenland Nutritional Board. Seven of the ten recommendations were translatable into operational criteria, mainly based on judgments from the authors grounded on the Nordic Nutrition Recommendations of 2004 (22). The operational criteria can be seen in Figure 2.

![Dietary Recommendations](image)

We identified five dietary patterns (54). The standard diet was characterized by <25 E% from traditional food items (marine mammals, fish, caribou, musk ox), <20 E% from imported red meat and <25% from “unhealthy food items” (fast food, snacks, sweets and soda pop) – which does not live up to the recommendations of the

* traditional food is defined as seal, whale, walrus, fish caught in open water, musk ox, polar bear, reindeer, wild fowls and berries.

** n/a: not applicable.

Figure 2. The ten food-based dietary guidelines outlined by the Greenland Nutrition Board; the criteria used to derive the five dietary patterns used in study 3; and the five dietary patterns themselves.
Nutritional Board of Greenland for a balanced diet. The balanced diet complied with at least seven of the nine recommendations by the Nutritional Board. The imported meat diet had 20 E% or more from imported red meat (but less than 25 E% from traditional food items and less than 25 E% from unhealthy food items); the traditional diet had 25 E% or more from traditional food items (but less than 20 E% from unhealthy food items); and the unhealthy diet had 20 E% or more from unhealthy food items.

Analyses
For the associations between glycemic outcomes and dietary patterns we excluded individuals who were non-fasting and those with missing data on physical activity. The samples included 2,374 individuals with eligible data. The baseline characteristics were performed by chi-square test (categorical variables) or general linear model (GLM for continuous variables). The association between dietary patterns and clinical outcomes was tested by GLM with adjustments for sex, age, ethnicity, waist circumference, total energy intake, physical activity and smoking status. Physical activity (minutes/week) was log-transformed to achieve normal distribution. To analyse if dietary patterns were associated with T2DM or pre-diabetes we used logistic regression analysis with forced entry. We analysed the association between dietary patterns and T2DM, IFG and IGT with adjustments as reported in the conceptual framework figure 3. Forced entry was chosen to avoid dietary patterns being excluded as variables when they were not significant. We investigated the possibility of interactions between the variables.

Confounders
When studying the association between diet and diabetes, there are numerous potential confounders that should be considered before the analyses. In this study we defined confounders a priori based on experiences from former work in diabetes research. We tested simple associations and included the confounders associated with outcome (pre-diabetes, diabetes, insulin resistance and beta-cell function) and exposure (dietary patterns). Several behavioural factors have been identified as risk factors for IGT and IFG leading to T2DM. Increasing frequency of alcohol consumption has been shown to increase the risk of T2DM, when compared to those who abstain from drinking. This was not found for IGT (21). Smoking has shown contradictory results; it was recently found to be associated with elevated fasting plasma glucose in
men but not in women (55), whereas 2h plasma glucose was not affected. Another study found that the risk of T2DM seemed to be inversely related to smoking since current smokers have a lower risk of both T2DM and IGT (21) than non-smokers. A large meta-analysis found that active smoking was associated with an increased risk of diabetes (56). Physical inactivity was found to be related to the impairment of peripheral glucose uptake (insulin resistance) and is related mainly to IGT for this reason. Anthropometric studies in Inuit populations have shown that BMI might be overestimating the prevalence overweight and obesity in these communities (57). Waist circumference can be used as an alternative measurement of central fat distribution. Abdominal fat is a stronger risk factor than total fat mass for various cardiovascular complications, including diabetes (58;59). A family history of diabetes was found to be associated with elevated fasting glucose but not with 2h plasma glucose (18;60).

Figure 3. Conceptual model of the association between diet and glucose intolerance.

Confounders: age, sex, energy intake, physical activity, smoking and ethnicity. Maybe alcohol (?)
RESULTS

With a participation rate of 68% for Inuit respondents, the total study sample included 3,108 Inuit in the final data set (44% men) and an average (SD) age of 44.4 (14.8) years (range 18–95). The exclusion criteria used in each paper are shown in Table 4.

Table 4. Shows the population samples in papers 1, 2 and 3, as well as the exclusion criteria for each paper.

<table>
<thead>
<tr>
<th>2005–2010</th>
<th>Inuit Health in Transition</th>
<th>Exclusion criteria</th>
<th>N = 3,253 (45% men)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper 1</td>
<td>Ethnicity</td>
<td>145 Danes</td>
<td>2,752</td>
</tr>
<tr>
<td></td>
<td>Energy intake</td>
<td>356 participants</td>
<td></td>
</tr>
<tr>
<td><strong>Final sample Paper 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paper 2</td>
<td>Missing dietary data on Hg and FA</td>
<td>528</td>
<td></td>
</tr>
<tr>
<td><strong>Final sample Paper 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paper 3</td>
<td>Known diabetes</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Invalid physical activity data</td>
<td>174</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Not fasting</td>
<td>128</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exclusion of outliers (HOMA and HOMA-β)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><strong>Final sample Paper 3</strong></td>
<td></td>
<td></td>
<td>2,374</td>
</tr>
</tbody>
</table>

Participation rate varied by sex and age. Women participated in the data collection more often than men.
PART 1: TRADITIONAL FOOD INTAKE AND DIETARY RECOMMENDATIONS

The analyses revealed that the upper quartile of the study population with the highest intake of traditional food had the lowest actual intake of carbohydrates, but the highest intake of total fat and protein. Together with the lowest quartile of traditional food consumers, the upper quartile had the highest energy intake. The consumption of traditional food, which is mainly meat and blubber, contributed more to daily energy intake than imported meat; 21 E% vs. 14 E%, respectively. Traditional food intake came almost entirely from marine mammals. Sugar intake constituted 16% of total energy intake, but it decreased together with fibre intake for increasing consumption of traditional food, as illustrated in figure 4.

Figure 4 shows the dietary composition of fibre and added sugar with increasing contribution of traditional food in the diet (E%) among Inuit in Greenland.

Figure 5 illustrates that with increasing amounts of traditional food in the diet, the FA profile improves: saturated fat decreases, though not significantly, between the quartiles, and both monounsaturated and polyunsaturated fat increase (p<0.0001). N3 FA especially contributes to increasing amounts of PUFA intake as the amount of traditional food in the diet increases.
Figure 5. The FA profile of the diet changes when traditional food contribution increases. Traditional food E% are shown in quartiles 1–4; and saturated fat (SFA), monounsaturated fat (MUFA), total polyunsaturated fat (total PUFA) and N3 FA (N3 PUFA) are shown in E%.

Marine mammals contributed to 12% of daily energy intake in the traditional diet; this included blubber and dried meat as well. Seal meat in particular contributed 7% of the protein intake whereas seal blubber contributed 9% of the fat intake. Muktuk was a large contributor to MUFA and PUFA intake.

In figure 6 the five food items that contributed most to selected nutrients are shown. Marine mammals contributed with 12% of the daily energy intake. Seal meat in particular contributed to protein intake with 7% whereas seal blubber contributed with 9% of the fat intake. Muktuk is a large contributor to monounsaturated FA (MUFA) and PUFA intake.

Candy, soda pops, and cakes contributed with 16 % of the energy intake and sugar added to coffee and tea contributed a lot to the carbohydrate intake (12 %). The groups “Other foods” in each diagram in figure 6 represents all the rest of the food items that contributed to the nutrients; however, with a much lower contribution.
Figure 6 shows the five most contributing foods to energy, fibre, saturated fat, and added sugar among Greenland Inuit 2005-10 (N=2752).
The adherence of respondents to nutritional recommendations is detailed in Table 5, which shows the proportion of the total population that complied with the recommendation as well as the proportion that consumed above and below the recommended amounts. The majority of the participants (69%) consumed more than the recommended amounts for added sugar, while 64% consumed more than 30 E% of total fat. As seen in figure 6, most of the saturated fat comes from butter or other fat-spreads used on bread or from cheese. The majority also consumed a low-fibre diet; only 18% had a diet with 25–35 grams of fibre/day and just 5% reached 35 grams/day or more. Furthermore, only one-third of the participants reached the daily recommended intake of 5–10 E% from PUFA. However, 87% reached the recommended 1 E% from N3 FA.

Table 5. Adherence to the recommended macronutrient distribution range set by the Nordic Nutrition Recommendations of 2004 (NNR 2004). Percentages are weighted according to age and residence in order to give a countrywide estimate. Inuit in Greenland 2005–2010 (N=2,752).

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>NNR 2004</th>
<th>Proportion beneath the recommendations</th>
<th>Proportion in compliance with the recommendations</th>
<th>Proportion above the recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrates</td>
<td>50–60 E%</td>
<td>53%</td>
<td>31%</td>
<td>16%</td>
</tr>
<tr>
<td>Fibre</td>
<td>Between 25–35 g/day</td>
<td>77%</td>
<td>18%</td>
<td>5%</td>
</tr>
<tr>
<td>Added sugar</td>
<td>Max. 10 E%</td>
<td>n/a</td>
<td>31%</td>
<td>69%</td>
</tr>
<tr>
<td>Protein</td>
<td>10–20 E%</td>
<td>1%</td>
<td>52%</td>
<td>47%</td>
</tr>
<tr>
<td>Fat</td>
<td>Max 25-30 E%</td>
<td>13%</td>
<td>23%</td>
<td>64%</td>
</tr>
<tr>
<td>Saturated fat</td>
<td>Max 10 E%</td>
<td>n/a</td>
<td>58%</td>
<td>42%</td>
</tr>
<tr>
<td>Monounsaturated fat</td>
<td>10-15 E%</td>
<td>34%</td>
<td>53%</td>
<td>13%</td>
</tr>
<tr>
<td>Polyunsaturated fat</td>
<td>5-10 E%</td>
<td>66%</td>
<td>31%</td>
<td>3%</td>
</tr>
<tr>
<td>N3 FA</td>
<td>1 E%</td>
<td>13%</td>
<td>n/a</td>
<td>87%</td>
</tr>
</tbody>
</table>
Conclusions

- An increase in consumption of traditional food is associated with a diet low in fibre, low in carbohydrates and high in fat and protein. Unsaturated fat and polyunsaturated fat, especially N3 FA, are associated with a higher intake of traditional food.
- Bread, candy and imported meat contribute most to the total energy intake.
- Bread is the largest contributor to dietary fibre.
- Muktuk contributes to both monounsaturated fat and polyunsaturated fat intake. Dietary saturated fat is mainly provided by butter, margarine and cheese products.
- There is a very high compliance to N3 FA intake, which makes up the majority of the PUFA intake. However, there is a low adherence to total PUFA intake.
- Furthermore, there is a low compliance to recommended intakes of sugar, total fat and fibre.
- Only 8% of women and 2% of men were compliant with the recommendation.

PART 2: ASSESSMENT OF MARINE FOOD INTAKE

The mean age for the final study population was 45 (15) years. In table 6, baseline characteristics are shown for the total study population. The prevalence of smoking was high. Among the 86 % active or former smokers 65 % were still active smokers. The majority of the population consumed alcohol; however, 1 % only drank on a daily basis whereas 20% drank on a weekly basis.
Table 6. Mean (sd) of biomarkers and calculated intakes from FFQ. Adult Inuit in Greenland 2005-10. N = 2224

<table>
<thead>
<tr>
<th>Unit</th>
<th>Total Mean (sd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>44.7 (14.7)</td>
</tr>
<tr>
<td>% of former or current smokers</td>
<td>86.3</td>
</tr>
<tr>
<td>% drinking alcohol</td>
<td>90.3</td>
</tr>
<tr>
<td>Erythrocyte membrane eicosapentanoeic acid</td>
<td>2.4 (1.6)</td>
</tr>
<tr>
<td>Erythrocyte membrane docosahexaenoic acid</td>
<td>4.3 (2.2)</td>
</tr>
<tr>
<td>Erythrocyte membrane total N3 FA</td>
<td>10.0 (4.2)</td>
</tr>
<tr>
<td>Whole blood mercury</td>
<td>21.1 (24.7)</td>
</tr>
<tr>
<td>Calculated energy</td>
<td>8734.1 (3113.3)</td>
</tr>
<tr>
<td>Calculated traditional food</td>
<td>168.5 (144.2)</td>
</tr>
<tr>
<td>Calculated seal</td>
<td>46.9 (64.3)</td>
</tr>
<tr>
<td>Calculated whale</td>
<td>27.6 (50.4)</td>
</tr>
<tr>
<td>Calculated fish</td>
<td>61.2 (67.4)</td>
</tr>
<tr>
<td>Calculated frequency of seal consumption</td>
<td>10.5 (11.7)</td>
</tr>
<tr>
<td>Calculated frequency of whale consumption</td>
<td>4.2 (7.2)</td>
</tr>
<tr>
<td>Calculated frequency of fish consumption</td>
<td>15.4 (13.7)</td>
</tr>
<tr>
<td>Calculated eicosapentanoeic acid</td>
<td>2.4 (2.4)</td>
</tr>
<tr>
<td>Calculated docosahexaenoic acid</td>
<td>1.8 (1.8)</td>
</tr>
<tr>
<td>Calculated total N3 FA</td>
<td>7.6 (6.1)</td>
</tr>
<tr>
<td>Calculated intake of mercury</td>
<td>38.9 (45.2)</td>
</tr>
</tbody>
</table>

Unadjusted and adjusted Pearson correlations are presented in table 7 between calculated and measured intake of whole blood mercury µg/L, erythrocyte membrane total N3 FAs, EPA, and DHA as percentages of total fat. The correlations only decreased slightly after age-adjustment. Partial correlation coefficients ranged from r = 0.16 (DHA) to 0.56 (Mercury). Table 7 also presents the back-transformed values of the mean difference of biomarkers and FFQ values and the back-transformed limits of agreement. For mercury it is indicated from the Bland Altman mean difference, that the FFQ gives a higher value compared with the biomarkers. The opposite was found for N3 FA, EPA and DHA, where the mean difference is above zero. The Bland Altman plots in figure 7 illustrate the agreement between log-transformed calculated intake and log-transformed measured biomarker. The best agreement is observed between
calculated and measured mercury, where the fitted line is close to the mean difference. From all the plots it is clear, that a large variability between the calculated and measured values exists. The difference between the two methods becomes larger at higher intake of FAs, and the plots indicate that the FFQ underestimates the intake of total N3 FA, EPA, and DHA compared with the biomarker. Univariate analyses showed that alcohol consumption (abstainer vs. drinkers) and total energy intake (kJ/day) was associated to both whole blood mercury and FAs. Smoking (non-smokers vs. former smokers/current smokers) was only related to whole blood mercury. In table 8 and table 9 linear regression models for the association with whole blood mercury, erythrocyte membrane N3 FA, EPA, and DHA with seal, whale and fish consumption are shown. Analyses were adjusted for age, total energy intake, alcohol consumption and smoking status.

Table 7. Correlation coefficients of calculated mercury intake and whole blood mercury, and dietary FA intake and erythrocyte membrane FA. Values for Bland Altman mean difference between biomarker and FFQ value with limits of agreement were transformed back by 10^x. Adult Inuit in Greenland 2005-08. (N = 2224)

<table>
<thead>
<tr>
<th>Nutrient/biomarker</th>
<th>Crude Pearson correlation</th>
<th>P-value</th>
<th>Partial correlation*</th>
<th>P-value</th>
<th>Geometric mean difference biomarker – calculated FFQ</th>
<th>Bland Altman limits of agreement (LOA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total N3 FA % of total fat</td>
<td>0.22</td>
<td>&lt;0.0001</td>
<td>0.20</td>
<td>0.0001</td>
<td>0.74</td>
<td>-0.53; 5.48</td>
</tr>
<tr>
<td>EPA % of total fat</td>
<td>0.40</td>
<td>&lt;0.0001</td>
<td>0.38</td>
<td>0.0001</td>
<td>0.23</td>
<td>-0.60; 2.79</td>
</tr>
<tr>
<td>DHA % of total fat</td>
<td>0.18</td>
<td>&lt;0.0001</td>
<td>0.16</td>
<td>0.0001</td>
<td>1.76</td>
<td>-0.12; 7.62</td>
</tr>
<tr>
<td>Mercury in μg</td>
<td>0.57</td>
<td>&lt;0.0001</td>
<td>0.56</td>
<td>0.0001</td>
<td>-0.43</td>
<td>-0.90; 2.29</td>
</tr>
</tbody>
</table>

*age adjusted correlation
Figure 7 Bland-Altman plots for mercury, total N3 FA, EPA, and DHA with best fitted line. Differences in biomarkers and calculated nutrients plotted against the mean of the two methods for adult Inuit in Greenland (N=2224)
Table 8. Linear multiple regression analyses for the association with whole blood mercury and erythrocyte membrane N3 FA, EPA, DHA estimated quantity of seal, whale, and fish among adult Inuit in Greenland 2005-08 (N=2224).

<table>
<thead>
<tr>
<th>Variables entered in prediction-model for whole blood mercury (µg/L)</th>
<th>β</th>
<th>95 % CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seal (10g/day)</td>
<td>1.069</td>
<td>(1.064; 1.076)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Whale (10g/day)</td>
<td>1.028</td>
<td>(1.021; 1.035)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Fish (10g/day)</td>
<td>1.005</td>
<td>(1.000; 1.009)</td>
<td>0.09</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variables entered in prediction-model for erythrocyte membrane total N3 FA</th>
<th>β</th>
<th>95 % CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seal (10g/day)</td>
<td>1.016</td>
<td>(1.012; 1.019)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Whale (10g/day)</td>
<td>1.005</td>
<td>(1.002; 1.009)</td>
<td>0.01</td>
</tr>
<tr>
<td>Fish (10g/day)</td>
<td>1.007</td>
<td>(1.005; 1.009)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variables entered in prediction-model for erythrocyte membrane EPA</th>
<th>β</th>
<th>95 % CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seal (10g/day)</td>
<td>1.023</td>
<td>(1.021; 1.026)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Whale (10g/day)</td>
<td>1.007</td>
<td>(1.002; 1.009)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Fish (10g/day)</td>
<td>1.009</td>
<td>(1.007; 1.012)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variables entered in prediction-model for erythrocyte membrane DHA</th>
<th>β</th>
<th>95 % CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seal (10g/day)</td>
<td>1.012</td>
<td>(1.007; 1.014)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Whale (10g/day)</td>
<td>1.005</td>
<td>(1.000; 1.009)</td>
<td>0.01</td>
</tr>
<tr>
<td>Fish (10g/day)</td>
<td>1.007</td>
<td>(1.005; 1.012)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

*models were adjusted for age, total energy intake (kJ/day), smoking, and alcohol consumption.
Table 9. Linear multiple regression analyses for the association with whole blood mercury and erythrocyte membrane N3 FA, EPA, DHA frequency of seal, whale, and fish meals among adult Inuit in Greenland 2005-08 (N=2224).

<table>
<thead>
<tr>
<th>Variables entered in prediction-model for whole blood mercury (µg/L)</th>
<th>β</th>
<th>95 % CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency seal 1 meal/month</td>
<td>1.035</td>
<td>(1.030; 1.038)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Frequency whale 1 meal/month</td>
<td>1.019</td>
<td>(1.014; 1.023)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Frequency fish 1 meal/month</td>
<td>0.998</td>
<td>(0.998; 1.002)</td>
<td>0.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variables entered in prediction-model for erythrocyte membrane total N3 FA</th>
<th>β</th>
<th>95 % CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency seal 1 meal/month</td>
<td>1.009</td>
<td>(1.007; 1.009)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Frequency whale 1 meal/month</td>
<td>1.002</td>
<td>(1.000; 1.005)</td>
<td>0.04</td>
</tr>
<tr>
<td>Frequency fish 1 meal/month</td>
<td>1.002</td>
<td>(1.000; 1.005)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variables entered in prediction-model for erythrocyte membrane EPA</th>
<th>β</th>
<th>95 % CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency seal 1 meal/month</td>
<td>1.012</td>
<td>(1.011; 1.014)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Frequency whale 1 meal/month</td>
<td>1.002</td>
<td>(1.000; 1.007)</td>
<td>0.008</td>
</tr>
<tr>
<td>Frequency fish 1 meal/month</td>
<td>1.002</td>
<td>(1.002; 1.005)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variables entered in prediction-model for erythrocyte membrane DHA</th>
<th>β</th>
<th>95 % CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency seal 1 meal/month</td>
<td>1.007</td>
<td>(1.005; 1.009)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Frequency whale 1 meal/month</td>
<td>1.002</td>
<td>(1.000; 1.005)</td>
<td>0.1</td>
</tr>
<tr>
<td>Frequency fish 1 meal/month</td>
<td>1.002</td>
<td>(1.000; 1.005)</td>
<td>0.005</td>
</tr>
</tbody>
</table>

*models were adjusted for age, total energy intake (kJ/day), smoking, and alcohol consumption.

Small but highly significant associations were found between estimated intake of seal, whale and fish and each of the biomarkers. Only fish intake was not associated with whole blood mercury (table 8). A similar pattern was found between frequency of seal, whale and fish meals and the four biomarkers; however, no association was found between fish meals and whole blood mercury or between whale meals and DHA.
Conclusions

- The best linear association between biomarker and calculated intake from FFQ was found for mercury and EPA.
- The Bland Altman plots for measuring agreement showed the best fitted lines between measured whole blood mercury and calculated mercury intake and for measured and calculated DHA.
- It seems from the plots that FFQ under-estimate the mercury intake compared with the measured values in whole blood, however, the opposite is seen for all the FA: the FFQ under-estimate intake compared to values measured in erythrocyte membranes.
- Seal was the marine food item that showed best association with whole blood mercury and erythrocyte membrane FA.
- Estimating portion sizes did not improve the association between marine food intake and measured biomarkers.

PART 3: DIETARY PATTERNS AND GLUCOSE INTOLERANCE

The study included 2,327 participants. In the initial dietary analyses we found a significantly higher energy intake among men compared with women (mean [SD] 9,890 kJ [3,195] vs. 7,987 [2,815], p<0.0001). We also found that men had a higher intake of traditional food compared with women (22% vs. 19%, p=0.001). Between men and women we found no significant difference in the intake of imported meat and unhealthy, sugar-dense foods such as candy, cakes and soda pop (data not shown). However, we found that fruit and vegetables contributed more to the diets of women than those of men (7% vs. 4%, respectively, p<0.0001).

Table 10 and 11 shows baseline characteristics for the five dietary patterns. The traditional dietary pattern was different from the other patterns in regard of ethnicity. The majority of the participants with a traditional pattern were Inuit with 4 Inuit grandparents. Smoking was very prevalent and all dietary patterns had high percentage of active smokers. Alcohol consumption was not prevalent on a daily basis in any of the dietary patterns though prevalent on a monthly basis. Due to the weak association between the dietary patterns in alcohol consumption, this confounder was not included in further analyses.

<table>
<thead>
<tr>
<th></th>
<th>Imported meat (N=76)</th>
<th>Traditional diet (N=293)</th>
<th>Balanced diet (N=18)</th>
<th>Unhealthy diet (N=272)</th>
<th>Standard diet (N=328)</th>
<th>All p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td>43 (11)</td>
<td>51 (13)</td>
<td>48 (16)</td>
<td>40 (15)</td>
<td>46 (14)</td>
<td></td>
</tr>
<tr>
<td>Ethnicity (% fully Inuit)</td>
<td>94</td>
<td>68</td>
<td>68</td>
<td>81</td>
<td>84</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>95 (0.14)</td>
<td>92 (0.14)</td>
<td>100 (0.13)</td>
<td>90 (0.14)</td>
<td>93 (0.14)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Physical activity (min/week)</td>
<td>850 (2.78)</td>
<td>1131 (3.52)</td>
<td>1067 (5.08)</td>
<td>1031 (4.91)</td>
<td>1203 (2.53)</td>
<td>0.4</td>
</tr>
<tr>
<td>Daily energy intake (kJ/day)</td>
<td>9684 (0.36)</td>
<td>9560 (0.41)</td>
<td>9507 (0.25)</td>
<td>9536 (0.42)</td>
<td>8914 (0.43)</td>
<td>0.06</td>
</tr>
<tr>
<td>Carbohydrate E%</td>
<td>39</td>
<td>37</td>
<td>41</td>
<td>53</td>
<td>48</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Protein E%</td>
<td>22</td>
<td>25</td>
<td>27</td>
<td>17</td>
<td>19</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Fat E%</td>
<td>39</td>
<td>38</td>
<td>32</td>
<td>30</td>
<td>33</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Saturated fat g/d</td>
<td>38 (14)</td>
<td>29 (13)</td>
<td>29 (13)</td>
<td>27 (11)</td>
<td>28 (12)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>N3 FAs g/d</td>
<td>5 (6)</td>
<td>13 (8)</td>
<td>9 (8)</td>
<td>6 (4)</td>
<td>5 (3)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Fibre g/d</td>
<td>20 (8)</td>
<td>17 (7)</td>
<td>25 (6)</td>
<td>17 (8)</td>
<td>23 (10)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Sugar E%</td>
<td>12 %</td>
<td>11 %</td>
<td>6 %</td>
<td>26 %</td>
<td>13 %</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Current smokers</td>
<td>63</td>
<td>67</td>
<td>44</td>
<td>68</td>
<td>64</td>
<td>0.3</td>
</tr>
<tr>
<td>Previous smokers</td>
<td>20</td>
<td>21</td>
<td>33</td>
<td>19</td>
<td>22</td>
<td>0.6</td>
</tr>
<tr>
<td>Daily drinkers</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0.8</td>
</tr>
<tr>
<td>Weekly drinkers</td>
<td>30</td>
<td>34</td>
<td>13</td>
<td>27</td>
<td>23</td>
<td>0.06</td>
</tr>
<tr>
<td>Monthly drinkers</td>
<td>64</td>
<td>56</td>
<td>73</td>
<td>65</td>
<td>68</td>
<td>0.06</td>
</tr>
<tr>
<td>Family history of diabetes</td>
<td>12</td>
<td>7</td>
<td>14</td>
<td>6</td>
<td>11</td>
<td>0.2</td>
</tr>
<tr>
<td>IFG</td>
<td>5</td>
<td>24</td>
<td>28</td>
<td>14</td>
<td>12</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>IGT</td>
<td>7</td>
<td>5</td>
<td>11</td>
<td>2</td>
<td>3</td>
<td>0.03</td>
</tr>
<tr>
<td>T2DM</td>
<td>10</td>
<td>16</td>
<td>17</td>
<td>10</td>
<td>9</td>
<td>0.06</td>
</tr>
</tbody>
</table>
Table 11. Behavioural and clinical characteristics of the five dietary patterns for women. N=1387

<table>
<thead>
<tr>
<th></th>
<th>Imported meat (N= 120)</th>
<th>Traditional diet (N= 308)</th>
<th>Balanced Diet (N= 108)</th>
<th>Unhealthy diet (N=380)</th>
<th>Standard diet (N= 471)</th>
<th>All p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td></td>
</tr>
<tr>
<td>Women (N=1387)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethnicity (% fully Inuit)</td>
<td>82</td>
<td>93</td>
<td>85</td>
<td>86</td>
<td>88</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>90 (0.13)</td>
<td>91 (0.17)</td>
<td>96 (0.14)</td>
<td>89 (0.16)</td>
<td>89 (0.15)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Physical activity (min/week)</td>
<td>1187 (2.68)</td>
<td>1187 (3.27)</td>
<td>1510 (1.96)</td>
<td>1155 (2.59)</td>
<td>1180 (2.89)</td>
<td>0.3</td>
</tr>
<tr>
<td>Daily energy intake (kJ/day)</td>
<td>7869 (0.37)</td>
<td>7779 (0.49)</td>
<td>7358 (0.44)</td>
<td>7855 (0.43)</td>
<td>6967 (0.45)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Carbohydrate E%</td>
<td>39</td>
<td>38</td>
<td>45</td>
<td>54</td>
<td>50</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Protein E%</td>
<td>22</td>
<td>26</td>
<td>24</td>
<td>17</td>
<td>19</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Fat E%</td>
<td>39</td>
<td>36</td>
<td>31</td>
<td>29</td>
<td>31</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Saturated fat g/d</td>
<td>31 (11)</td>
<td>25 (13)</td>
<td>22 (11)</td>
<td>23 (11)</td>
<td>21 (9)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>N3 FAs g/d</td>
<td>7 (6)</td>
<td>11 (9)</td>
<td>7 (6)</td>
<td>5 (5)</td>
<td>4 (3)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Fibre g/d</td>
<td>18 (7)</td>
<td>15 (7)</td>
<td>26 (11)</td>
<td>15 (7)</td>
<td>20 (8)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Sugar E%</td>
<td>11</td>
<td>11</td>
<td>5</td>
<td>27</td>
<td>12</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Current smokers</td>
<td>75</td>
<td>70</td>
<td>52</td>
<td>77</td>
<td>65</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Previous smokers</td>
<td>14</td>
<td>20</td>
<td>29</td>
<td>15</td>
<td>22</td>
<td>0.004</td>
</tr>
<tr>
<td>Daily drinkers</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1.0</td>
</tr>
<tr>
<td>Weekly drinkers</td>
<td>16</td>
<td>21</td>
<td>16</td>
<td>19</td>
<td>18</td>
<td>0.8</td>
</tr>
<tr>
<td>Monthly drinkers</td>
<td>81</td>
<td>66</td>
<td>66</td>
<td>70</td>
<td>72</td>
<td>0.05</td>
</tr>
<tr>
<td>Family history of diabetes</td>
<td>8</td>
<td>13</td>
<td>18</td>
<td>12</td>
<td>12</td>
<td>0.2</td>
</tr>
<tr>
<td>IFG</td>
<td>7</td>
<td>17</td>
<td>13</td>
<td>8</td>
<td>11</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>IGT</td>
<td>4</td>
<td>6</td>
<td>7</td>
<td>6</td>
<td>9</td>
<td>0.1</td>
</tr>
<tr>
<td>T2DM</td>
<td>2</td>
<td>14</td>
<td>12</td>
<td>8</td>
<td>10</td>
<td>0.005</td>
</tr>
</tbody>
</table>
The traditional dietary pattern was different from the other patterns in regard to ethnicity. The majority of the participants with a traditional dietary pattern were classified as Inuit and had four Inuit grandparents. All dietary patterns had a high percentage of smokers. Alcohol consumption was not prevalent on a daily basis in any of the dietary patterns, though it was prevalent on a monthly basis. Due to the weak association between the dietary patterns and alcohol consumption, this confounder was not included in further analyses. The percentage of the study population that complied with all seven FBDG, and hence could be grouped into the “balanced diet” category, was small. Only 8% of the women and 2% of the men in this study had a balanced dietary pattern.

Table 12 shows that fasting plasma glucose was significantly higher among respondents following the traditional dietary pattern compared to those with a standard diet. Fasting insulin and beta-cell function were significantly lower in those with a traditional dietary pattern compared to those with a standard diet. Furthermore, insulin resistance was lower among participants with a traditional diet compared to those with a standard diet, although not significantly so. Sex, age and waist circumference were associated with all clinical outcomes. Physical activity and smoking were significantly associated with fasting insulin, 2h-glucose, insulin resistance and beta-cell function. Energy intake was not significantly associated with any of the outcomes shown in Table 12. Ethnicity was only significant for 2h blood glucose. No significant differences were found for 2h plasma glucose.
Table 12. Mean values (95% CI) of fasting and 2h plasma glucose, fasting insulin, insulin resistance and beta-cell function among adult Inuit (N=2,327, missing 47). Analyses are adjusted for age, sex, ethnicity, waist circumference, physical activity, smoking and total energy intake. P-values beneath mean (95% CI) indicate the difference between the respective dietary patterns and the standard diet.

<table>
<thead>
<tr>
<th></th>
<th>Mean (95% CI)</th>
<th>Imported meat (N=192)</th>
<th>Traditional diet (N=591)</th>
<th>Balanced diet (N=123)</th>
<th>Unhealthy diet (N=636)</th>
<th>Standard diet (N=785)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fasting plasma glucose (mmol/L)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.52 (5.43; 5.59)</td>
<td><strong>5.73</strong> (5.68; 5.78)</td>
<td>5.61 (5.50; 5.71)</td>
<td><strong>5.67</strong> (5.62; 5.71)</td>
<td>5.56 (5.52; 5.59)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P = 0.3</td>
<td>P &lt;0.0001</td>
<td>P = 0.6</td>
<td>P &lt;0.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2 hr plasma glucose (mmol/L)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.47 (5.22; 5.73)</td>
<td><strong>5.68</strong> (5.53; 5.84)</td>
<td>5.55 (5.22; 5.89)</td>
<td><strong>5.68</strong> (5.55; 5.84)</td>
<td>5.46 (5.34; 5.59)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P = 0.9</td>
<td>P = 0.03</td>
<td>P = 0.7</td>
<td>P = 0.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fasting insulin (pmol/L)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>39.6 (37.1; 42.4)</td>
<td><strong>36.1</strong> (35.3; 38.1)</td>
<td>37.1 (34.1; 40.4)</td>
<td>40.0 (38.5; 41.5)</td>
<td>38.7 (37.6; 40.0)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P = 0.4</td>
<td>P = 0.04</td>
<td>P = 0.3</td>
<td>P = 0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Insulin resistance (HOMA-IR)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.54 (1.43; 1.65)</td>
<td>1.44 (1.38; 1.51)</td>
<td>1.44 (1.31; 1.58)</td>
<td><strong>1.56</strong> (1.51; 1.63)</td>
<td>1.48 (1.43; 1.54)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P = 0.3</td>
<td>P = 0.3</td>
<td>P = 0.5</td>
<td>P = 0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Beta-cell function (HOMA-β)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>58.3 (54.7; 62.1)</td>
<td><strong>48.7</strong> (46.9; 50.4)</td>
<td>52.2 (48.1; 56.7)</td>
<td>54.9 (52.8; 56.8)</td>
<td>55.8 (54.1; 57.61)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P = 0.2</td>
<td>P &lt;0.0001</td>
<td>P = 0.2</td>
<td>P = 0.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In Figure 8, associations between each dietary pattern and T2DM, IFG and IGT are illustrated by a forest plot with an odds ratio (OR) and 95% CI (standard diet=reference; OR=1). A total of 1,581 participants were characterized as normal glucose tolerant. The traditional dietary pattern showed significantly higher OR for IFG and T2DM, whereas no significant association was found for IGT. The balanced diet and the unhealthy diet also showed higher OR for IFG and T2DM but neither of these associations were significant.
As with the glycemic outcomes shown in Table 12, age and waist circumference were associated with all glycemic outcomes. Sex was only associated with IFG and IGT. The interaction between sex and dietary pattern was not significant for the associations with IFG and T2DM, but was significant for IGT. However, when we stratified the analyses based on sex, the association was not statistically significant because there were only 18 participants with a balanced dietary pattern. No interactions were found for the other dietary patterns. The small number of cases in the balanced dietary pattern category is the reason for the wide confidence interval for IGT in Figure 8. OR for IFG was lower for women compared to men (OR: 0.7 [0.5; 0.9]). Full Inuit heritage was associated with IGT (OR= 2.9 (1.2; 6.9)) vs. partly Inuit. The same trend was observed for DM, however not significant (OR=1.8 (0.97; 3.36)). Smoking was the only confounder associated with IFG (previous smoker: OR [95% CI] 1.4 [0.8; 2.4] and current smoker: OR 2.2 [1.4; 3.6]).
Conclusions

- Traditional food is positively associated with T2DM, IFG and fasting plasma glucose, and negatively associated with beta-cell function when compared to a standard diet.
- No significant associations were found between IGT and dietary patterns.
- An imported meat diet resulted in lower fasting plasma glucose, lower insulin resistance and higher beta-cell function, as well as the lowest OR for IFG and T2DM.
- Age and waist circumference were positively associated with all glycaemic outcomes. Male gender and smoking were associated with IFG, full Inuit heritage with IGT, and physical inactivity with T2DM
DISCUSSION AND FUTURE PERSPECTIVES

Difficulties of dietary assessment

This study presents evidence of difficulties in adherence to nutrition recommendations and regarding dietary patterns based on dietary guidelines and their association with glucose intolerance. Traditional food plays a major role in these associations as it can benefit dietary composition; however, a traditional dietary pattern is also associated with various aspects of glucose intolerance. This study also highlights the difficulties of collecting dietary data, especially in a non-western context. Conversely, the study has the obvious strengths of the representativeness of the population and the high response rate compared with other Arctic studies (61). Issues related to the above conclusions are discussed in the following.

Advantages and limitations of FFQ and biomarkers

The FFQ is commonly used in large population studies (6). It is a retrospective method suitable for obtaining data on average intake over prolonged periods, usually months, and is connected with different bias. In this study the most obvious bias is the recall bias (respondent memory lapses), with incorrect estimation of season length and frequency of consumption also playing a role in the quality of FFQ data. In Greenland the population is very diverse in many aspects, and it is unknown whether the perception of season length and perceptions of when a food was eaten differ between village and urban areas. The questionnaire is a pre-printed list of foods, and there is always a risk that foods were eaten that were not included in the listed food items. There is also a risk of interviewer bias as since the FFQ was a part of a larger interviewer-guided questionnaire, the interviewer conducting the interview could have misunderstood parts of the questionnaire. We checked for errors in regard to interviewers and found no systematic mistakes. Another potential bias could be in the generation of FFQ data where missing values of season length and portion size were replaced with median values of these variables. Overall, this can lead to a systematic underestimation of certain nutrients (6). Lastly, within food variation in nutrient density may have occurred due to storage, processing and differences in preparation practices. Nevertheless, we tried to decrease the various bias by testing the FFQ prior to the data collection and by ensuring that the interviewers were bilingual and were able to perform the interview according to the participant’s preference in either Danish
or Greenlandic. As a typical bias in data, this study also suffered from lack of information in nutrient databases. The nutrient tables for traditional food in the Arctic, and specifically for Greenland, were scarce and often values had to be found elsewhere, e.g. in Canadian references. Most of the nutrient values for traditional foods were based on few observations (typically < 5), which increased the variation of the mean value. Furthermore, some food items were not found in the nutrient tables; accordingly, we had to find alternative food items (e.g. the value for some birds were substituted by the values for seal, because of missing data on values). These limitations in the use of FFQ influenced the analyses regarding agreement and regarding biomarkers and the linear associations tested.

Another disadvantage of the FFQ is the relatively inaccurate estimation of quantitative intake compared with methods such as dietary record or 24h recall. This inaccuracy is caused by incompleteness in the foods listed and in the estimation of portion sizes. Estimation of portion size is a complex and difficult task for the respondent. Therefore it is worth considering whether this task is necessary for the study. This study found that estimating portion sizes for the consumption of marine foods did not improve the association with biomarkers compared with the association with frequency of consumption only. Additional estimation of portion size in an FFQ can introduce extra variation in data due to inter-individual variation in the estimation of frequency and portion size. Combinations of foods in various dishes might influence the portion sizes of single food items, and difference in eating occasions might add extra variation to the portion size. An earlier study tested the use of semi-quantitative FFQ vs. FFQ and found a better association between frequency of consumption and whole blood mercury than between estimated portion sizes and whole blood mercury (62). However, portion sizes improved the association with whole blood mercury among the younger participants (<36 years of age).

The results of the present study could also be influenced by errors in the data obtained by the biomarkers. Biomarkers as a dietary assessment method have several advantages but also limitations, which could explain our results. Biomarkers as a method have fewer errors compared to the FFQ (63). Biomarker data are not influenced by missing data in food lists or influenced by combination of foods or culturally different dishes unknown to the researchers. Biomarkers can provide a
measure of nutritional status or, as seen with mercury, a status of accumulation caused by consumption of specific foods (marine food). The results of this study showed that seal was the single marine food with the best association with both whole blood mercury and erythrocyte membrane fatty acids. Fontaine et al found that marine mammal meat contributed to a 1.17 µg/L (values were reported log-transformed: \( \beta = 0.07 \)) increase in whole blood mercury for each gram/day extra consumption of marine mammal meat (12). This supports our results: our regression model of whole blood mercury showed that seal (10 gram/day) increased whole blood mercury by 1.069 µg/L (\( p<0.0001 \)). Fish consumption, both as quantity and frequency, had a lower association with biomarkers than seal did; nevertheless, fish constituted a relatively large part of the traditional food intake. This is supported by the results from Paper 1 where fish was not one of the contributing food items to any of the nutrients. Our study population had an average intake of 61.2(sd 67.49) gram fish per day compared with 46.9 (sd 64.3) gram seal per day. A possible explanation for the lack of effect from fish intake to predict our biomarkers could be that marine mammals, such as seal, are top-predator animals and are therefore the last step in the bioaccumulation of mercury. Greenlandic databases report that the average mercury content of marine fish in Greenland is 0.071 µg/gram wet weigh compared with 0.355 µg/gram wet weight in seal and a content of 0.583 µg/gram wet weight in toothed whale meat (64;65). From these values, the explanation for the lack of association with whole blood mercury from fish intake could be due to a lower average content of mercury in the various fish species vs. seal or whale. For FA as biomarkers, Lucas et al studied total N3 fatty acids in erythrocyte membrane as a biomarker for marine mammal and fish consumption among Inuit in Nunavik(66). They found that per gram marine mammal meat/day the erythrocyte membrane total N3 fatty acid increased by 1.15% (measured as % of total fatty acid content). In that study, fish also contributed to erythrocyte membrane total N3 fatty acid by an 0.37% increase per gram fish increase/day. In comparison, we found that erythrocyte membrane total N3 fatty acid increased by 1.016% for every 10 gram increased seal consumption and by 1.007% for every 10 gram consumed fish. Another possible explanation for the lack of agreement between measured and calculated fatty acids is the turnover and metabolism of fatty acids. In a supplementation study, Brown et al showed that the DHA content of erythrocyte membranes decreased more slowly than the EPA content
After 6 weeks the intervention was terminated. Eighteen weeks after supplementation had stopped, the EPA content had returned to baseline level, whereas DHA had not. This shows that there are differences in the metabolism of N3 fatty acids. We found the lowest association between measured and calculated DHA. It seems that EPA is a better biomarker for short-term intake (3–4 months) and DHA is a better biomarker for long-term intake (6 months or more). Our results were supported by a previous study that also found a lower association between DHA compared with EPA when erythrocyte values and FFQ data were compared. However, interestingly, the study also found that plasma EPA compared with erythrocyte EPA improved the agreement with calculated FFQ intake. Nevertheless, it is important to remember that when using erythrocyte membrane fatty acids as biomarkers, there is a constant turnover of fatty acids between plasma, erythrocyte membrane, adipose tissue and muscle tissue. Erythrocyte membrane fatty acids indicate a steady-state compartment as well as a compartment in transition with fatty acids that have not yet been delivered to the final body store. Mercury as a biomarker has the advantage of the known half-life that all metals possess. Elimination of mercury from the body occurs primarily from urine and faeces with an absorbed dose half-life of 1–2 months. As a biomarker, MeHg can be used because almost all MeHg is absorbed in the intestine, and it has been shown that during a long-term exposure a good relation between intake and blood values was found. This shows the advantage of using full blood mercury as a biomarker compared with erythrocyte membrane FA.

In this present study, one of the major limitations of biomarkers was their vulnerability regarding human intervention. The handling of biological specimens has an impact on the measurement of biomarkers. In 2008, all blood samples collected in Tasilaq were lost due to mistakes made during the transportation from Nuuk to Copenhagen. As a result, biomarkers were not available, and valuable data were lost; it clearly shows how vulnerable biological data are. Further, as this study also shows, both mercury and erythrocyte membrane fatty acids were correlated to and associated with the marine food items, but had we collected data by biomarkers only, we would not have known what various animals were consumed. Biomarkers provide information on food groups rather than detailed information on single food items, such as the FFQ does.
Traditional food and dietary composition

Taking into consideration the limitations of both biomarkers and FFQ as dietary assessment methods, the FFQ provided us with detailed data that the biomarkers could not identify. From a public health viewpoint, it was important to assess the compliance with the nutrition recommendations, and due to specificity of the dietary advice, the FFQ was the main method chosen for the two papers addressing nutrition recommendations. Adherence to nutrition recommendations in Greenland was overall low. Of special concern were fibre, added sugar, and total fat. One third of the participants did not comply with any of the dietary guidelines outlined by the Greenland nutrition board (33% of men and 34% of women adhered to the standard diet). In the following, some specific nutrients of concern are discussed.

In Greenland, 64% of the population exceed the recommended 30 E% for total fat. A national survey conducted among adult Danes during 2003–2006 showed that 79% exceeded the recommendations for fat intake (69). In line with this, 42% in our survey consumed more that 10 E% from saturated fat, with imported food such as margarine, butter, and cheese contributing to 27% of the SFA intake. These food items are easy to cut down on and margarine could be substituted by vegetable oils, which would contribute to an increased PUFA and MUFA intake. A study among Alaska Natives showed that an increasing proportion of traditional food in the diet resulted in increased fat consumption; however, it was mainly PUFA (70). All dietary patterns had a high energy contribution from fat. The unhealthy diet was lower in total fat than the other patterns because it was dominated by sugar-dense products.

Inuit in Greenland seem to have a low intake of N6 fatty acids. Nevertheless, the majority eat more than the recommended amounts of N3 fatty acids. This is mainly due to intake of muktuk, the fatty layer situated just below the skin of whales and seals. This fatty layer consists almost entirely of N3 fatty acids. The ratio of N3 to N6 is of metabolic importance. In general, N3 has shown anti-inflammatory effects associated with a lower risk of cardio-vascular disease (71). The high N3 fatty acid in the Inuit diet is also beneficial, taking into account the high prevalence of obesity in this population. Obesity, in particular abdominal fatness, is associated with a high production of inflammatory markers. The combination of low-grade inflammation and altered metabolism of adipocytes plays an important aetiologic role in the
development of insulin resistance and type 2 diabetes (72). At first, it could seem concerning that we found very low compliance with PUFA recommendations. Traditional marine food is high in PUFA, hence we found that the majority consumed accordingly to the recommendations of N3 FA. Therefore, the low compliance with PUFA recommendations must be attributed to low N6 fatty acid intake. N6 fatty acids are abundant in vegetable oils, which could be used in the cooking of food instead of butter or margarine. Butter, in particular, contributed to the consumption of total fat and saturated fat. Saturated fat intake was highest in the “Imported meat diet”. Not surprisingly, because imported meat covers beef, lamb and pork, and the associated products can be dense in fat. PUFA intake from marine mammals consists mainly of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which in a study among Inuit in Nunavik have shown to decrease the blood content of triglycerides and increase the content of high-density lipoprotein (HDL); accordingly, they have a protective effect against cardiovascular disease and incidence of diabetes (31;73). Other studies have found that EPA and DHA can have differential effects on lipoproteins: specifically, DHA increased low density lipoprotein (LDL cholesterol), whereas EPA had no effect (32) or lowered LDL (74). According to a new meta-analysis, DHA reduces triglycerides and increases HDL more than EPA does (74). It is concluded, in a recent review, that plasma N3 fatty acids have a preventive effect on obesity due to reduced appetite and food intake. These conclusions were drawn from both human and animal studies (75). Furthermore, our results showed that a high consumption of traditional food is associated with an improved dietary fat profile with significantly higher amounts of monounsaturated and polyunsaturated fat. From the perspectives of fatty acid, increasing the intake of marine mammal could have health benefits for the population.

The majority of the population had a lower intake of fibre and carbohydrate than recommended by NNR2004. Furthermore, a high intake of traditional food resulted in a low fibre intake. The low fibre intake is of concern, but it is not surprising: low fibre consumption has been reported in other Arctic populations, including Inuit (76). In rural Alaska, only 1% of Alaska Native men and 4% of women met the recommended fibre intake (24). These studies correspond well to the findings of Paper 1, namely that fibre was scarce in traditional food. Both a whole-grain dense diet and a high-fibre diet have shown to reduce the risk of developing diabetes (77). However, Paper
3 showed that a balanced diet with the highest fibre content gave increased OR for both diabetes and pre-diabetic stages, albeit the associations were not significant. The balanced dietary pattern also had the disadvantage of having the smallest size. Adherence to all the dietary guidelines compared with non-compliance (standard diet) did not result in lower fasting glucose, insulin resistance or higher insulin secretion.

Added sugar has shown to be a dietary risk factor for development of obesity (78). Further, added sugar in soft drinks may promote inflammation, insulin resistance, and decreased beta cell function, a risk factor for development of T2DM (33;79). This present study found that added sugar was contributed by sugar added to tea or coffee and from soda pops and hence it is relevant to discuss consumption of sugar from liquids. The unhealthy dietary pattern had the highest content of added sugar. The intake of added sugar decreased with increased consumption of traditional food. Furthermore, the traditional dietary pattern had a sugar E% similar to that of the imported meat diet, and the standard diet had approximately half the energy intake from sugar compared with the unhealthy diet. However, the association between the traditional dietary pattern and IFG and T2DM seemed comparable to the association between the unhealthy dietary pattern and IFG and T2DM. The majority of sugar intake was contributed by carbonated beverages and sugar added to coffee and tea. There are several issues regarding sugar added to liquids. One is the lack of satiety when drinking instead of chewing calories. The mechanistic motion of chewing results in a large production of intrinsic hormones secreted in the gut (gastric factors) which is one of the mechanism in satiety and control of food intake. The fact that the energy is consumed in a liquid form can increase the energy/min consumed compared with energy intake in a solid form that would provide fibre that would decrease the energy density of the meal. Sugar-dense liquids can be consumed in relatively large amounts and often carbonated drinks and sugar-dense beverages are consumed between meals that influence the food intake at the following meal(80). Incomplete compensation for the extra intake of energy at the following meal consumption might lead to weight gain that increases the risk of type 2 diabetes(81). A large meta-analysis found that sugar-sweetened beverages, e.g. lemonade containing fructose fractions, could promote accumulation of visceral adiposity, increase hepatic de novo lipogenesis and hypertension (33). Furthermore, high loads of sugar increase the dietary glycaemic index and high glycemic load that in some studies are associated
with insulin resistance (82) and glucose intolerance (83;84). Though some studies have also found no associations (85). This corresponds well with Table 12. The unhealthy diet was significantly associated with higher fasting plasma glucose, higher 2h glucose and higher insulin resistance compared with the standard diet. In a Greenland context, a recent study among Inuit did not find any association between glycemic index, glycemic load and prevalence of diabetes; however, associations between glycemic index and fasting plasma glucose and furthermore between glycemic load and insulin resistance and insulin secretion were found significant, though, very small (86).

**Dietary patterns and glucose tolerance**

In this study, a traditional diet, defined as the consumption of at least 25 E% of traditional food, was significantly associated with T2DM, higher fasting glucose and lower beta-cell function. It has been found that fasting plasma glucose increased with the consumption of marine food (40). Raised fasting plasma glucose could reflect impaired insulin secretion (87;88). This corresponds well with our findings that the traditional dietary pattern was associated with significantly lower beta cell function. Furthermore, our study showed that the traditional food in relation to diabetes or IFG gave significantly higher odds ratio for both disease outcomes. Previous research found that a dietary pattern high in sugar and processed meat increased the risk of T2DM (89). The unhealthy dietary pattern had the highest content of added sugar. Among both men and women, the E% was 1.5 times the recommended intake of maximum 10 E% sugar according to the Nordic Nutrition Recommendations 2004. A follow-up study showed that an unhealthy dietary pattern high in processed food, sugar, and red meat increased the risk of T2DM (OR: 1.56 (CI: 1.32; 1.93) (38). In Paper 3 it was also seen that the unhealthy diet gave higher insulin resistance and higher fasting and 2h plasma glucose, which corresponds well with previous research (90). A recent intervention showed that a low-fat, high carbohydrate diet with supplemental N3 fatty acids (1.24 g/day) resulted in the largest cardio-metabolic benefits compared with a high-fat iso-energetic diet or a low-fat high carbohydrate diet without supplementation(91). The only nutritional aspect comparable between the unhealthy and the traditional dietary pattern is the low fibre intake. It is doubtful whether this is what gives the similarities regarding IFG, T2DM and fasting and 2h-
glucose outcomes. A recent publication showed that both IFG and T2DM were decreasing with increasing urbanization (5). It could be questioned whether the analyses in Paper 3 should have been adjusted for residence. However, analyses were adjusted in the early initial analyses and the effects of dietary patterns were still present. Residence was purposely not included in the analyses because urbanisation is a factor that covers various—and some unknown—other factors that influence glucose intolerance. The initial analyses also showed that women had decreased OR for IFG compared with men, which is in accordance with previous research (92).

This study has the advantage of data on ethnicity and medical records of diagnosed diabetes. By excluding individuals with known diabetes, the results of Paper 3 were not influenced by individuals on medication or changes in lifestyle in relation to treatment of diabetes. Other studies have found ethnicity to play a significant role in both insulin resistance and beta-cell function (93;94). In this present study, ethnicity was associated with 2h blood glucose and IGT. Nonetheless, there are some specific issues related to the glucose intolerance measurements that need to be addressed. One is the use of the HOMA index. The HOMA index is commonly used in larger epidemiological studies to assess insulin resistance and beta-cell function. The calculations require only fasting glucose and fasting insulin values. Earlier studies showed that the HOMA index correlated well with the hyperinsulinaemic glucose clamp, which is usually perceived as the gold standard for glucose intolerance assessment (95;96). Other studies have found that the HOMA index is more reliable as a measure of insulin resistance compared with other measures and indexes, such as fasting glucose/insulin ration (97). However, this study by Keskin et al was conducted in children and adolescents and another study found limitations in the prediction of insulin resistance and beta-cell function with the HOMA index in older people (98). This indicates that age might influence the use of the HOMA index. How that may affect out results is unknown, but in this present study we included only adults (18+ years). Another factor that might influence the association between glucose intolerance and dietary patterns is residual confounding. Alcohol consumption might be an influencing factor, even though the associations were found non-significant between the various dietary patterns. Alcohol consumption was found to inhibit gluconeogenesis in overnight fasting healthy men which means that alcohol consumption could influence the fasting plasma glucose levels (99). Other influencing
factors could be environmental contaminants, which have been associated with both diabetes and decreased insulin secretion (100-102). Another study found a significant association between contaminants and low insulin secretion, although no associations were found between the contaminants and diabetes, impaired glucose tolerance, or insulin resistance (103). An important future perspective for research must be to study the relation between various environmental pollutant and glucose intolerance. The Greenland Inuit is a very relevant study population for this exposure-disease scenario due to the high prevalence of glucose intolerance combined with a high level of contaminant intake through the diet.
CONCLUSIONS

In conclusion, based on the findings of this study, the public health recommendations for the population are to focus nutrition recommendations on decreasing added sugar intake (especially sugar intake from drinks), substituting margarine and butter with vegetable oils, and increasing the intake of fibre. For the association between traditional food and glucose intolerance, it is recommended to study the effect of ethnicity since a genetic susceptibility may confound the associations. Studies on the association between environmental contaminants should be conducted in a Greenlandic context to evaluate whether traditional food consumption should be limited, as it is in other arctic regions (104).

An important issue in this study is the methodology of dietary data collection. Data collected by two different methods were to some extent associated to each other, but the main message is, that researchers should choose methods for dietary data collection that is appropriate for answering their research question. In this study the FFQ was the appropriate method to answer the research aims I and III.

In the following, specific conclusions in relation to each of the posted aims will be outlined.

Aim

I: To describe modern Inuit consumption of traditional food and adherence to recommended macronutrients distribution range.

Conclusion

Traditional food was mainly provided by marine mammals such as seal, whale, and walrus. Individuals with high consumption of traditional food had a diet low in fibre, low in carbohydrate and high in fat and protein. Unsaturated fat and polyunsaturated fat, especially N3 FA, was associated with a higher intake of traditional food. Muktuk was the single traditional food item that contributed most to both monounsaturated fat and polyunsaturated fat intake. Dietary saturated fat was mainly provided by butter, margarines and cheese products. In general there was a very high compliance to N3 FA intake which contributed
to the majority of the PUFA intake. Though there was a low adherence to total PUFA intake.

Bread, candy and imported meat contributed most to the total energy intake. Fibre was mainly provided by consumption of bread. Intake of added sugar, and total fat were too high and fibre intake too low for the majority of the population. Only 8% of women and 2% of men were compliant with the current dietary recommendation suggested by the Nutrition Board of Greenland

Aim

II: To evaluate the agreement between biomarkers and FFQ data.

Conclusion

- The best linear association between biomarker and calculated intake from FFQ was found for whole blood mercury and erythrocyte membrane EPA; nevertheless, the best fitted lines in Bland Altman plots were found between mercury and DHA. Estimating portion sizes did not improve the association between marine food intake and measured biomarkers, where seal intake showed the strongest association with biomarkers.

Aim

III: To analyse the association between dietary patterns and glucose intolerance

Conclusion

Traditional food was positively associated with T2DM, IFG, fasting plasma glucose, and negatively with beta-cell function compared to a standard diet. The unhealthy dietary pattern was associated to higher insulin resistance, higher fasting – and 2h plasma glucose. Imported meat diet was associated with lower fasting plasma glucose, lower insulin resistance and higher beta cell function and the lowest OR for IFG and T2DM.

No significant associations were found between IGT and dietary patterns.
Summary

The purpose of this study was to describe the modern Inuit’s consumption of traditional food and adherence to the recommended macronutrient distribution range, to evaluate the dietary assessment methods, and to analyse the association between dietary patterns and glucose intolerance. Data for analyses included 3108 adult Inuit (18+ years, 43% men, with an average (sd) age of 45 (15) years). Data were obtained from 2005–10 by a semi-quantitative food frequency questionnaire including traditional food consumption (25 foods) and imported foods and liquids (43 types). Data on whole blood mercury, erythrocyte membrane fatty acids, fasting glucose and insulin, and 2h glucose were obtained from blood samples. Anthropometric data included height, weight and waist circumference. Furthermore, data were obtained on physical activity, alcohol consumption, smoking, ethnicity, family history of diabetes, diagnosis of diabetes, and sex and age. Insulin resistance and insulin secretin were calculated by using the HOMA index whereas impaired fasting glucose, impaired glucose tolerance and type 2 diabetes were defined using the definitions from World Health Organization (WHO). Traditional food derived mainly from marine mammals such as seal, whale, and walrus. Individuals with a high consumption of traditional food had a diet low in carbohydrate, fibre and added sugar and high in polyunsaturated fat and protein. Saturated fat was provided mainly by butter, margarine, and cheese products, and fibre was provided mainly by consumption of bread. Intake of added sugar was too high and mainly provided through liquids such as pops and sugar added to tea and coffee. The intake of total fat was too high as well and fibre intake too low for the majority of the population. A very small proportion of both men (2 %) and women (8 %) could comply with all seven food-based dietary guidelines outlined by the Nutrition Board of Greenland. The best linear association between biomarkers and calculated intake from FFQ was found for mercury and eicosapentaenoic acid; nevertheless, the best agreements were found for calculated and measured mercury and calculated and measured docosahexaenoic acid. Estimating portion sizes did not improve the association between marine food intake and measured biomarkers, where seal intake had the strongest association with biomarkers. Traditional food is positively associated with T2DM, IFG, fasting plasma glucose and negatively associated with beta-cell function compared with a standard diet. The unhealthy dietary pattern was associated with higher insulin resistance and
higher fasting and 2h plasma glucose. Future perspectives include an increased focus on limiting intake of added sugar and saturated fat, and increasing fibre intake in the population. The associations between glucose intolerance and traditional foods need further research into ethnic susceptibility of diabetes among Inuit and the potential role of environmental pollutants on development of glucose intolerance.
Resumé

observeret mellem kviksølv og docosahexaensyre. Sæl var den fødevar af traditionel kost som havde den stærkeste association til samtlige biomarkører og endvidere viste det sig at associationen var uberørt af om indtaget af sæl var opgjort i frekvens af måltider eller angivet i mængde. Relationen mellem kostmønstre og glukoseintolerance viste at et traditionelt kostmønster karakteriseret ved minimum 25 E% fra traditionelle fødevarer gav signifikant højere odds ration for både IFG og T2DM, samt nedsat insulin sekretion og forhøjet fasteblodglukose. Et usundt kostmønster, karakteriseret ved mindst 25 E% fra sukkerholdige fødevarer såsom kager, slik og sodavand, samt et højt indtag af junkfood og halvfabrikata, resulterede i signifikant højere insulinresistens, og signifikant højere faste og 2 timers plasma glukose. Konklusionen på dette studie er at fremtidige ernæringsanbefalinger og rådgivning i Grønland må fokusere på at nedbringe befolkningen indtag af total fedt, mættet fedt, tilsat sukker og få befolkningen til at indtage flere fibre ved mere frugt og grønt. Associationen mellem traditionel kost og glukose intolerance kalder på videre forskning inden for etnisk disponering for diabetes blandt grønlændere og desuden om miljøforureningsstoffer og tungmetaller ophobet i marine pattedyr kan have indflydelse på relationen mellem traditionel kost og diabetes.
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