British Journal of Nutrition (2013), **109**, 928–935
doi:10.1017/S0007114512002097

Vitamin D status in Greenland is influenced by diet and ethnicity: a population-based survey in an Arctic society in transition

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(Submitted 11 January 2012 – Final revision received 18 April 2012 – Accepted 18 April 2012 – First published online 8 June 2012)

Abstract

Vitamin D status as measured by plasma 25-hydroxyvitamin D (25(OH)D) is important to human health. Circumpolar people rely on dietary sources and societal changes in the Arctic are having profound dietary effects. The objective of the present study was to determine plasma 25(OH)D status and factors important to plasma 25(OH)D in populations in Greenland. Inuit and non-Inuit aged 50–69 years in the capital in West Greenland (latitude 64°15′N) and in a major town and remote settlements in East Greenland (latitude 65°35′N) were surveyed. Supplement use and lifestyle factors were determined by questionnaires. Inuit food scores were computed from a FFQ of seven traditional Inuit and seven imported food items. 25(OH)D_2 and 25(OH)D_3 levels were measured in the plasma. We invited 1 % of the population of Greenland, and 95 % participated. 25(OH)D_3 contributed 99·7 % of total plasma 25(OH)D. Non-Inuit had the lowest median plasma 25(OH)D of 41 (25th–75th percentile 23–53) nmol/l compared with 64 (25th–75th percentile 51–81) nmol/l in Inuit ($P<0·001$). Plasma 25(OH)D was below 20 and 50 nmol/l in 13·8 and 60·1 % of participants, respectively, with Inuit food item scores below 40 % ($P<0·001$), and in 0·2 and 25·0 % of participants, respectively, with higher scores ($P<0·001$). The Inuit diet was an important determinant of plasma 25(OH)D ($P<0·001$) and its effect was modified by ethnicity ($P=0·005$). Seal ($P=0·005$) and whale ($P=0·015$) were major contributors to plasma 25(OH)D. In conclusion, a decrease in the intake of the traditional Inuit diet was associated with a decrease in plasma 25(OH)D levels, which may be influenced by ethnicity. The risk of plasma 25(OH)D deficiency in Arctic populations rises with the dietary transition of societies in Greenland. Vitamin D intake and plasma 25(OH)D status should be monitored.

Key words: Plasma 25-hydroxyvitamin D: FFQ: Inuit Eskimos: Arctic Greenland: Lifestyle changes: Westernisation: Population-based study

Vitamin D deficiency is associated with adverse health outcomes and increases the risk of osteoporosis, falls and fractures[1–8]. Epidemiological evidence has linked low plasma 25-hydroxyvitamin D (25(OH)D) to a number of inflammatory, infectious, cardiovascular and metabolic disorders, and with cancers[9–19]. Thus, vitamin D is important for human health.

The endogenous production of 25(OH)D depends on the UVB-mediated conversion of 7-dehydrocholesterol to previtamin D_3 and further isomerisation to vitamin D_3 in the skin[10]. This depends on exposure to sunlight and plasma 25(OH)D levels in groups of Caucasian individuals decrease with increasing latitude[9,10,19,20]. Thus, low plasma levels of 25(OH)D are seen in, for example, Scandinavian populations[21,22] even during the summer[19]. Very low levels of 25(OH)D may be found in Arctic populations characterised by low sun exposure and heavy outdoor clothing.

Diet provides yet another source of plasma 25(OH)D, with free-living fish and sea mammals being particularly rich in vitamin D[9,19,23,24]. These dominate the traditional Inuit (Eskimo) diet[19,25,26] and the Inuit consider seal and whale blubber to be of particular dietary value. This may compensate

Abbreviation: 25(OH)D, 25-hydroxyvitamin D.

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for the lack of exposure to the sun and thus of dermal vitamin D production in Arctic residents.

Transition of Greenlandic societies started around 1960 and has occurred at different paces in different parts of Greenland[27], so that, today, settlements, towns and the capital city display different degrees of Westernisation[26,27]. This has influenced the use of the traditional Inuit diet, which has decreased[26,27], and this in turn has the potential to influence plasma 25(OH)D[25]. Furthermore, obesity rates in Inuit have increased in parallel with transition[28]. This is associated with lower plasma 25(OH)D in other populations[10] and may have a similar effect in Inuit.

This led us to study dietary habits and plasma 25(OH)D in cohorts living in the capital city Nuuk in West Greenland and in the rural Ammassalik district in East Greenland. We evaluated the impact of dietary components on plasma 25(OH)D in Arctic population groups. In addition, we assessed the influence of ethnicity on plasma 25(OH)D.

Subjects and methods

Area of investigation

Nuuk (64°15′N, 51°35′W) in West Greenland is the capital city of Greenland with 13 000 inhabitants of whom 75 % are Inuit (Eskimo) and 25 % non-Inuit (Caucasians). Nuuk was established as a trading post under the Danish crown in 1728 and is now a modern city with access to a wide variety of food items including fast food, Italian food, Thai food and takeaways, supplementary to traditional Greenlandic food items. Furthermore, a wide variety of food items imported from Denmark is available in a number of stores.

The Ammassalik district (65°35′N, 38°00′W) in East Greenland was isolated until 1884 and is still today difficult to access by sea due to pack ice from the northern ice cap. It is sparsely populated with 2943 inhabitants (93 % Inuit) spread over an area of 243 000 km^2. Tasiilaq is the main town of the Ammassalik district, which has seven settlements. Tasiilaq has one store with a limited food selection and five minor shops. Each of the settlements has one store with a limited selection depending on access by sea and air.

Subjects and procedures

Participants and procedures have been described in detail previously[26]. We invited 50–69-year-old men and women, both Greenlanders (all Inuit) and non-Greenlanders (all Caucasian Danes), recorded and living at the address. The places selected for the investigation were Nuuk, Tasiilaq, and the settlements Tiniteqilaaq, Sermiligaaq, Kulusuk and Kuummiut in the Ammassalik district. Only the settlements with more than fifteen inhabitants in the selected age group were included. In Nuuk, names and addresses were obtained from the hospital registration system that keeps records of all inhabitants of Nuuk. A random sample of 25 % of the total population aged 50–69 years was selected. The hospital registration system had not been regularly updated and for the investigation in Ammassalik, names and addresses were obtained from the National Civil Registration System in which every person living in Denmark, the Faeroe Islands and Greenland is registered. We invited 225 persons in Nuuk, 184 in Tasiilaq, nineteen in Tiniteqilaaq, twenty-eight in Sermiligaaq, fifty-two in Kulusuk, fifty-three in Kuummiut, and 95 % participated. A Greenlander (Inuit) was defined as an individual born in Greenland with both parents born in Greenland.

The present study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures were approved by the Commission for Scientific Research in Greenland (reference no. 2010-8). All subjects gave informed written consent in Danish or Greenlandic by the participant's choice.

The local hospital porter or the nursing station attendant delivered a letter of invitation. The investigation took place at the local hospital or nursing station or by request as home visits. A physical examination was performed including height without shoes, weight in indoor clothing and recording of major disabilities. Participants were interviewed by a Greenlandic interpreter or by one of the investigating doctors (S. A., P. L. and B. H.), completing a questionnaire in either Danish or Greenlandic as appropriate for the participant. Information regarding age and sex was obtained from the National Civil Registration System. Information on lifestyle patterns and dietary habits was obtained by questionnaires. Questions were asked as written in the questionnaires. The same interpreter was used in Nuuk, Tasiilaq and all settlements.

Dietary habits

An interview-based FFQ was used to assess dietary habits. It included seven traditional Inuit (seal, whale, wild fowl, fish, reindeer, musk ox and hare) and seven imported food items (pre-cooked meals, potatoes, vegetables, butter, cheese, eggs and fresh fruit). These food items had been selected because they were typical to the diet in Greenland and they have been used previously[26]. For each food item, six different frequency categories were given from 'never' to 'daily intake'. A frequency score was calculated based on the average number of days per month the food item was ingested[26]. Inuit food items scored positively and imported food items scored negatively. The sum of frequency scores for all food items consumed by each participant was calculated and individuals were categorised as follows: diet group 1, >80 %; diet group 2, 60–80 %; diet group 3, 40–60 %; diet group 4, 20–40 %; diet group 5, <20 % Inuit food item scores on a scale where 100 % was purely Inuit foods and 0 % was purely imported food. We did not assess portion size for practical reasons but food-frequency scores were validated by cross-check questions as well as by a biomarker of the intake of traditional Inuit foods[26].

The intake of vitamin D-containing supplements was evaluated by asking the frequency of intake. Supplements were presented to one of the investigating doctors for evaluation. Contents and type of vitamin D differed between supplements available. Vitamin D content was evaluated based on the interview if no supplement was presented. Subjects were classified by daily intakes (yes/no).

Plasma 25-hydroxyvitamin D assay

Plasma 25(OH)D levels were analysed by isotope dilution liquid chromatography–tandem MS (LC–MS/MS) as described earlier[29]. Calibrators traceable to a NIST standard reference material (SRM972) were used (ChromSystems).

Statistics

Results are presented as medians with 25th and 75th percentiles. The plasma 25(OH)D groups were compared using non-parametric statistics: Mann–Whitney *U* test for comparison of two groups; Kruskal–Wallis test for comparing several groups; Kendall's τ for the relationship between the groups. Plasma 25(OH)D followed the normal distribution ($P=0{\cdot}17$), and linear regression models were used with plasma 25(OH)D as the dependent variable. Interaction was tested in multivariate logistic regression analysis. Explanatory variables were diet group, participant group, ethnic origin, use of supplements, BMI, age, sex and alcohol intake (average number of units per week). Diet, participant group and origin were investigated individually in the multivariate linear regression analysis due to covariance between these. Random selection of participants in Nuuk was performed using MedStat (Astra). Data were processed and analysed using Corel Quattro Pro 8 (Corel Corporation) and the Statistical Package for the Social Sciences version 13.0 (SPSS, Inc.). A *P* value of less than 0·05 was considered significant.

Results

For the present study, 1 % of the population of Greenland was invited and the participation rate was 95 %. The characteristics of the participants are given in Table 1. In the case of non-Inuit, seven had one parent born in Greenland while ninety-four had neither parent born in Greenland. Non-Inuit were more frequent users of vitamin preparations than Inuit (Table 1). Non-Inuit were skilled labour from Denmark and included more men than women ($P<0{\cdot}001$). Also, there

Table 1. Descriptive information on participants in the diet and vitamin D survey in East and West Greenland

(Number of participants and percentages)

	Non-Inuit*		Inuit in Nuuk		Inuit in Tasiilaq		Inuit in settlements			
	n	%	*n*	%	*n*	%	*n*	%	*P*†	*P*‡
Number of participants										
All	101	100	150	100	141	100	143	100		
Taking vitamin D-containing supplements	22	21·8	15	10·0	5	3·5	3	2·1	< 0·001	0·004
Sex										
Men	80	79·2	70	46·7	80	56·7	79	55·2	< 0·001	0·17
Women	21	20·8	80	53·3	61	43·3	64	44·8		
Taking vitamin D-containing supplements										
Men	15	14·9	6	4·0	3	2·1	1	0·7	0·70	0·49
Women	7	6·9	9	6·0	2	1·4	2	1·4		
Age (years)										
50–59	85	84·2	87	58·0	87	61·7	85	59·4		
60–69	16	15·8	63	42·0	54	38·3	58	40·6	< 0·001	0·81
BMI (kg/m²)										
Men§										
< 30	65	81·3	45	78·9	69	87·3	72	91·1	0·16	0·12
30 +	15	18·7	12	21·1	10	12·7	7	8·9		
Women§										
< 30	19	90·5	51	76·1	46	78·0	48	76·2	0·54	0·96
30 +	2	9·5	16	23·9	13	22·0	15	23·8		
Smoker‖										
Present	57	56·5	111	74·0	108	76·6	109	76·2		
Past	18	17·8	16	10·7	14	9·9	19	13·3		
Never	26	25·7	22	14·7	19	13·5	15	10·5	0·008	0·75
Alcohol use (units)¶										
< 7	56	55·4	92	61·3	88	62·4	94	65·7		
7–21	32	31·7	50	33·3	46	32·6	37	25·9		
> 21	12	11·9	2	1·3	5	3·5	12	8·4	< 0·001	< 0·001
Hunting**										
Trade	2	2·0	8	5·3	22	15·6	45	31·5		
Leisure	39	38·6	44	29·3	52	36·9	53	37·0		
Rarely	60	59·4	93	62·0	65	46·1	45	31·5	< 0·001	< 0·001

* Including seven participants of mixed origin.
† χ^2 test for comparing proportions among all groups.
‡ χ^2 test for comparing proportions among Inuit.
§ BMI increased from settlement to town to city in Inuit men (trend, $P=0{\cdot}010$) but not in women (trend, $P=0{\cdot}39$).
‖ Information missing for one participant.
¶ Estimated units of alcohol per week. Information missing for nine participants.
** Information missing for seven participants.

were fewer non-Inuit than Inuit in the age group of 60–69 years and the mean age was lower (men $P=0.001$, women $P=0.005$; Table 1) because some leave Greenland when retiring. The study cohorts represented different levels of Westernisation as illustrated by hunting habits (Table 1). The two participants categorised as non-Inuit who reported hunting as a trade were of mixed origin.

Dietary habits

Dietary habits differed between the participant groups (Fig. 1). Of the participants, 93 % of Inuit in settlements had a food-frequency score of more than 60 % traditional foods compared with 86 % of Inuit in Tasiilaq, 59 % of Inuit in Nuuk and 3 % of non-Inuit. Conversely, 83 % of non-Inuit reported a food-frequency score of more than 60 % imported foods, while this was 14 % of Inuit in Nuuk and 1·4 % of Inuit in both Tasiilaq and settlements. Differences in dietary habits were marked between Inuit and non-Inuit ($P<0.001$) as well as between the Inuit groups ($P<0.001$). No seasonal differences in Inuit food frequency were reported.

Vitamin D

Plasma 25(OH)D_3 contributed 62·30 nmol/l (99·7 %) to the overall mean of 62·50 nmol/l of total 25(OH)D in the plasma, while 25(OH)D_2 contributed only 0·3 %. This proportion was 0·2 % in Inuit and 1·4 % in non-Inuit not taking vitamin D-containing supplements ($P=0.005$).

Diet and vitamin D

Fig. 2 shows that there was a significant ($P<0.001$) difference in plasma 25(OH)D levels between the participants in the five diet groups. A diet based on mainly imported foods was associated with a mean total plasma 25(OH)D level of 36 nmol/l. This increased gradually ($P<0.001$) to 68 nmol/l in the group with a diet comprising mainly traditional Inuit food items. The dietary components reported by Inuit that contributed markedly to plasma 25(OH)D were seal ($P=0.005$) and whale ($P=0.015$).

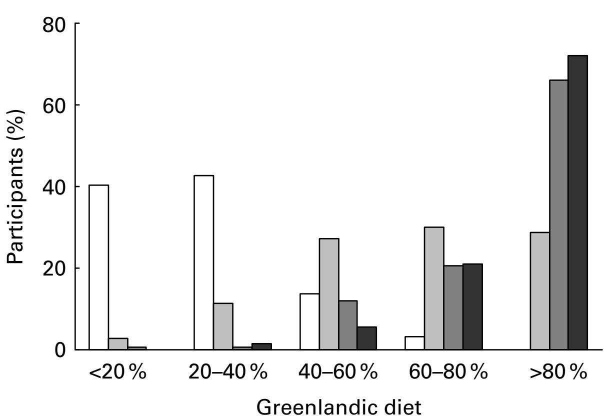

Fig. 1. Food-frequency scores among the population groups in the capital city Nuuk (latitude 64°15′N) in West Greenland and in the Ammassalik district (latitude 65°35′N) in rural East Greenland. Classification was based on frequencies of intake of seven traditional Inuit (seal, whale, wild fowl, fish, reindeer, musk ox and hare) and seven imported food items (pre-cooked meals, potatoes, vegetables, butter, cheese, eggs and fresh fruit). Six different frequency categories were given for each food item from 'never' to 'daily intake' and a frequency score was calculated. Individuals were categorised based on frequency scores on a scale where 100 % is purely Inuit foods and 0 % is purely imported foods. □, Non-Inuit; ▒, Inuit in city; ▓, Inuit in town; ■, Inuit in settlement.

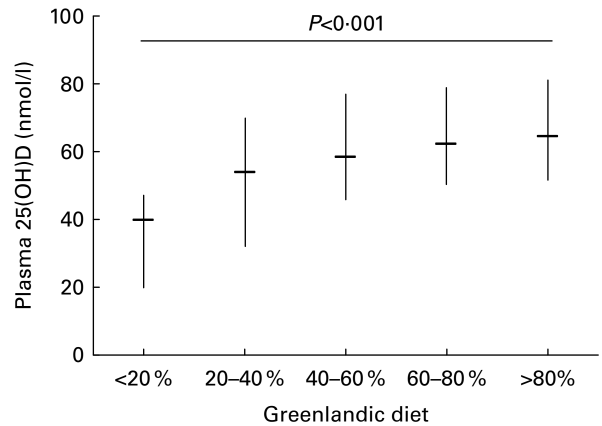

Fig. 2. Plasma 25-hydroxyvitamin D (25(OH)D) in each food-frequency group where 100 % is purely Inuit foods and 0 % is purely imported foods. Values are medians, with 25th and 75th percentiles represented by vertical bars.

The occurrence of plasma 25(OH)D below 50 nmol/l decreased with a higher intake of Inuit foods (Fig. 3) and 25(OH)D below 20 nmol/l was seen only in those with a low intake of traditional Inuit foods.

Ethnicity and vitamin D

Inuit had a higher plasma 25(OH)D than non-Inuit (Fig. 4). They also had the highest intake of traditional Inuit foods (Fig. 1). Table 2 lists the factors important to plasma 25(OH)D levels. Diet, lifestyle and ethnicity influenced plasma 25(OH)D in the adjusted analysis. A plasma 25(OH)D level below 50 nmol/l was more likely with Inuit food scores below 60 % ($P<0.001$; OR 5·4, 95 % CI 3·3, 8·8) and was modified by ethnicity (ethnicity × diet as an interaction term, $P=0.005$) in the multivariate logistic regression analysis.

Discussion

This is the first population-based study of the relationship between plasma 25(OH)D and the transition of societies in Greenland. We found that decreasing intake of the traditional Inuit diet was followed by a decrease in 25(OH)D in the plasma and an emerging vitamin D deficiency. Furthermore, seal and whale were major contributors to plasma 25(OH)D in populations in Greenland. Interestingly, ethnicity may influence the impact of dietary habits on plasma 25(OH)D.

Vitamin D synthesis in humans requires UVB exposure of the skin. In Caucasians, low UVB exposure in high-latitude countries is associated with an increased risk of low plasma 25(OH)D[1,9,10,19–21]. Greenland hosts the most northern

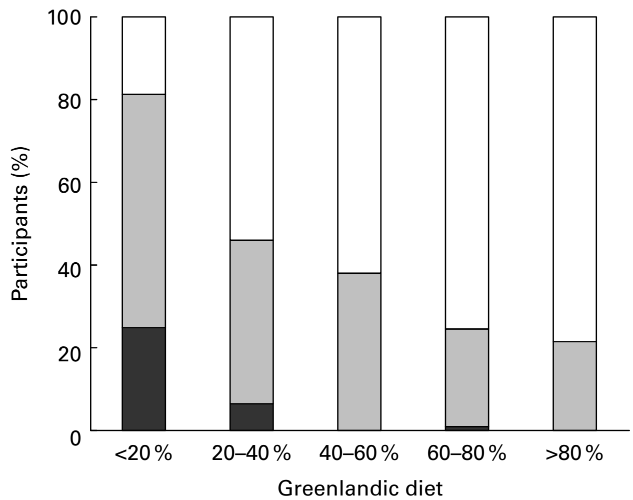

Fig. 3. Fraction of participants with plasma 25-hydroxyvitamin D below 20 nmol/l (■), between 20 and 50 nmol/l (▨) and above 50 nmol/l (□) for each food-frequency group where 100 % is purely Inuit foods and 0 % is purely imported foods.

habitats on Earth with a high solar zenith angle and consequently a very low intensity of UVB as the radiation is absorbed through its oblique passage through the atmosphere. Also, Greenland is an Arctic environment defined by the mean temperature being below 10°C during the warmest month. This influences clothing habits also during summer. Hence, very limited dermal production of vitamin D is expected in populations in Greenland and dietary sources are crucial to maintain adequate plasma 25(OH)D levels[25,30–32].

Vitamin D plays a pivotal role in skeletal health and low levels are associated with rickets, osteomalacia and osteoporosis with an increased risk of fractures[1,4–8,10]. Vitamin D may also be important for the functioning of other systems, such as the immune system[10,33]. As for the latter, tuberculosis is frequent in Greenland but is associated with both low and high plasma 25(OH)D[34]. As for the former, knowledge of Inuit skeletal health is limited. Bone mineral density did not differ between Inuit and non-Inuit in North Greenland[35]. On the other hand, more frequent hip fractures were reported in Alaska compared with southern states in the USA[36]. However, that study did not take into consideration differences in hours of sunlight and icy pavements. Still, plasma 25(OH)D is associated with the risk of falls[2,3] and myopathy[1,37,38], even though reports on falls in Greenland are lacking, and a sufficient plasma 25(OH)D status is important to human health[1,10,39].

Vitamin D is ample in traditional Inuit foods that comprise mainly marine mammals and fish, with blubber from seal and whale considered to be of particular value, in addition to caribou and birds[30]. Hence, dietary assessment interviews in a large group of Canadian Inuit have reported an intake of vitamin D exceeding the recommended adequate intake by up to 100 %[25]. It has also been reported that days with meals of traditional Inuit foods provided 25 μg vitamin D[30]. In contrast, dietary record studies have reported low intakes of vitamin D in the majority of Canadian Inuit in Nunavut and Northwest Territories[19,40–43]. A contributor to this discrepancy could be dietary transition as the intake of traditional Inuit foods is lower in younger compared with older individuals[30,44]. This was supported by plasma 25(OH)D in Greenland Inuit in Nuuk and Denmark classified by a weekly intake of marine mammals (yes/no)[45].

We performed a detailed classification of the diet by including non-Inuit and Inuit living in both an urban area with ample market foods and rural areas with limited availability of these and dependency on hunting and fishing. Participants were categorised based on the frequency of intake of traditional Inuit and imported market foods. This method is limited to the frequency of intake of food items used for main meals and does not include, for example, cereal foods. Also, we did not assess portion size. This hampers the accuracy of our estimates of food intakes but an equal influence on imported and traditional Inuit foods may be anticipated and hence a limited influence on the extent to which groups of subjects were categorised as traditional Inuit or Westernised eaters. Also, the method has been validated for description of the degree of adherence to the traditional Inuit diet[26]. The diet groups were associated markedly with plasma 25(OH)D and we found 88 % higher plasma 25(OH)D values in the group with the highest compared with the lowest intake of traditional Inuit foods. This is twice the difference found in the study with a more crude classification of the diet[45] but in keeping with the findings among Canadian Inuit[30–32]. Still, plasma 25(OH)D was 68 nmol/l in the group with the highest intake of traditional Inuit foods and thus not exceedingly high.

We found plasma 25(OH)D deficiency, defined as plasma 25(OH)D <50 nmol/l, in one in four subjects in the group with an Inuit diet score below 20 %. This was absent when the diet score was above 40 %. These diet scores correspond to less than weekly intake of Greenlandic food items and an

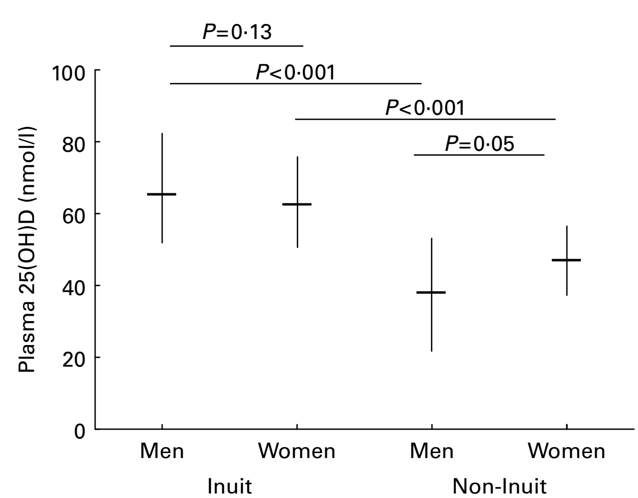

Fig. 4. Plasma 25-hydroxyvitamin D (25(OH)D) in Inuit and non-Inuit (Caucasian) men and women living in the capital city Nuuk in West Greenland and in the rural Ammassalik district in East Greenland.

Table 2. Factors important to plasma 25-hydroxyvitamin D (25(OH)D) in residents in Greenland
(β Coefficients and P values)

	Univariate model		Multivariate model*	
	β†	P	β†	P
Ethnicity	−0·41	<0·001	−0·36	<0·001
Lifestyle‡	0·16	<0·001	−0·11	<0·001
Diet§	−0·35	<0·001	−0·36	<0·001
Vitamin D supplements	0·10	0·018	−0·01	NS
BMI (kg/m^2)	0·02	NS	0·03	NS
Age (years)	0·10	0·016	−0·04	NS
Sex	0·06	NS	−0·03	NS
Alcohol	−0·03	NS	−0·05	NS

* Dependent variable was serum 25(OH)D and explanatory variables were weight, age, sex, alcohol intake, and either ethnicity, lifestyle or diet.
† β (Regression) coefficients were as follows: Inuit/non-Inuit; city/town/settlements; decreasing traditional Inuit diet; vitamin D supplement use −/+; increasing BMI; increasing age; men/women; increasing alcohol intake.
‡ Lifestyle represented by participant groups at different levels of Westernisation: non-Inuit; Inuit in city; Inuit in town; Inuit in settlement (as in Table 1).
§ Diet based on the diet groups calculated from the frequency of intake of seven Inuit and seven imported food items: diet group 1, >80 %; diet group 2, 60–80 %; diet group 3, 40–60 %; diet group 4, 20–40 %; diet group 5, 0–20 % Inuit food-frequency scores.

intake three times weekly or more, respectively. The group with an intake of traditional Inuit foods less than weekly had a 25(OH)D level that matched the finding in Nuuk using the more simple dietary classification[45]. The validity of this crude classification was supported by the present finding of seal and whale as the two major food items in the Inuit diet that were important for plasma 25(OH)D. However, such crude classification could not detect a difference in plasma 25(OH)D in a more recent study[34]. Thus, our more detailed classification of the traditional Inuit diet contributed to a more comprehensive description of the association between the traditional Inuit diet and plasma 25(OH)D, which is supported by the findings in Canadian Inuit[30].

We also found a higher plasma 25(OH)D in Inuit, who have darker skin compared with non-Inuit[43]. This is in keeping with the diet being the source of plasma 25(OH)D as whites tend to have higher 25(OH)D than do those with darker skin at lower latitudes, i.e. in the USA[46], the UK[47] and immigrants to Scandinavia[48]. The study by Rejnmark *et al.*[45] found lower plasma 25(OH)D among Inuit than among non-Inuit in Denmark. This may relate to skin pigmentation but further ethnic differences are supported by the present finding that ethnicity modified the influence of diet on plasma 25(OH)D. Our indirect measure of the influence of ethnicity was distinct (P=0·005) but should be confirmed in direct comparisons. Whether the difference relates to the bioavailability or metabolism of plasma 25(OH)D remains to be settled.

The capital city Nuuk hosts more obese subjects than does the town and settlements in East Greenland[28]. This could contribute to differences in plasma 25(OH)D levels as obesity reduces plasma 25(OH)D levels in other populations[10,49]. However, plasma 25(OH)D levels did not associate with BMI or weight in Inuit.

There was an association between the intake of traditional Inuit food items, the differences in the way of living between the study areas, the availability of imported food items, the frequency of fishing and hunting, and the fraction of non-Inuit. This limited the use of linear regression, but similar results were obtained using logistic regression, though this was less sensitive.

We studied only subjects aged 50–69 years. This might underestimate the impact of the transition away from traditional foods as older people eat more traditional foods[30,44]. Still, the older age group contributed to a high participation rate of 95 %, which supports the validity of the findings in the present population-based survey. Furthermore, the study included populations at the extremes of transition of societies in Greenland from the capital city Nuuk in West Greenland to remote settlements in East Greenland. Data on plasma 25(OH)D among populations in other areas of the more heavily populated west coast of Greenland are relevant as differences may apply in diet, lifestyle and genetics. Also, follow-up on the populations included here is recommended both to examine the effect of low plasma 25(OH)D in Inuit, and to follow up on the impact of future transition in dietary habits. Finally, younger people have a lower intake of traditional Inuit food items with a higher risk of 25(OH)D deficiency[30,44]. Thus, younger groups should be included in future studies of vitamin D intake and plasma 25(OH)D in Greenland.

In conclusion, we found low plasma 25(OH)D in older people in Greenland who had a low intake of Inuit food items. This observation was associated with the transition of societies in Greenland in keeping with the findings in indigenous populations in the Canadian Arctic. Furthermore, the present study suggests that ethnicity may contribute to differences in plasma 25(OH)D.

Acknowledgements

We gratefully acknowledge Karoline Berglund for her enthusiasm and thorough interviewing of Inuit. We are grateful for invaluable support from lægeklinikken in Nuuk, from Hans Chr. Florian Sørensen and the staff at the hospital in Tasiilaq, and from the staff at the nursing stations in Tiniteqilaaq, Sermiligaaq, Kuummiut and Kulusuk. This study was supported by grants from the following: Greenland Home Government; Karen Elise Jensen Foundation; Northern Jutland Research Foundation; Aalborg City Christmas Lottery; Danish Hospital Foundation for Medical Research, Region of Copenhagen, the Faeroe Islands and Greenland. The authors' contributions are as follows: S. A. contributed to the project conception, study design, raising of funds, data collection, analysis of the data and writing of the manuscript; P. L. participated in the project conception, study design, raising of funds, data collection, analysis of the data and reviewing of the manuscript; B. H. was responsible for the data collection and reviewing of the manuscript; K. K. participated in the study design and reviewing of the manuscript; L. H. was responsible for the analysis of the data, reviewing of the manuscript; L. M. contributed to the conception of the idea and writing of the manuscript. The authors declare that there are no conflicts of interest.

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