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Serum 25-hydroxyvitamin D, calcium and parathyroid hormone levels in Native and European populations in Greenland

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Abstract

Ca homoeostasis is important to human health and tightly controlled by powerful hormonal mechanisms that display ethnic variation. Ethnic variations could occur also in Arctic populations where the traditional Inuit diet is low in Ca and sun exposure is limited. We aimed to assess factors important to parathyroid hormone (PTH) and Ca in serum in Arctic populations. We included Inuit and Caucasians aged 50–69 years living in the capital city in West or in rural East Greenland. Lifestyle factors were assessed by questionnaires. The intake of Inuit diet was assessed from a FFQ. 25-Hydroxyvitamin D (25OHD$_2$ and 25OHD$_3$) levels were measured in serum as was albumin, Ca and PTH. The participation rate was 95 %, with 101 Caucasians and 434 Inuit. Median serum 25OHD (99·7 % was 25OHD$_3$) in Caucasians/Inuit was 42/64 nmol/l (25, 75 percentiles 25, 54/51, 81) ($P < 0·001$). Total Ca in serum was 2·33/2·29 mmol/l (25, 75 percentiles 2·26, 2·38/2·21, 2·36) ($P = 0·01$) and PTH was 2·7/2·2 pmol/l (25, 75 percentiles 2·2, 4·1/1·7, 2·7) ($P < 0·001$). The 69/97 Caucasians/Inuit with serum 25OHD <50 nmol/l differed in PTH ($P = 0·001$) that rose with lower 25OHD levels in Caucasians, whereas this was not the case in Inuit. Ethnic origin influenced PTH ($\beta = 0·27$, $P < 0·001$) and Ca ($\beta = 0·22$, $P < 0·001$) in multivariate linear regression models after adjustment for age, sex, BMI, smoking, alcohol and diet. In conclusion, ethnic origin influenced PTH, PTH response to low vitamin D levels and Ca levels in populations in Greenland. Recommendations are to evaluate mechanisms underlying the ethnic influence on Ca homoeostasis and to assess the impact of transition in dietary habits on Ca homoeostasis and skeletal health in Arctic populations.

Key words: **Parathyroid hormone: Calcium: Vitamin D: Ethnicity: Inuit**

Living in an Arctic environment challenges Ca homoeostasis in two ways. First, sun exposure is limited with low dermal production of vitamin D. Second, the traditional Inuit diet is mainly of marine origin and a poor source of Ca.

As for vitamin D, the endogenous production of 25-hydroxyvitamin D (25OHD) depends on exposure to sunlight, and serum 25OHD levels in groups of Caucasian subjects decrease with increasing latitude[1–3]. Thus, 25OHD levels should be low in Greenland Inuit[4,5] and it may have been a favourable trait for Arctic residents to develop mechanisms in order to adapt to lower levels of serum 25OHD[5–7]. Diet is another source of 25OHD, with fish and sea mammals being particularly rich in vitamin D[8,9]. These dominate the traditional Inuit diet[5,10,11], with seal and whale blubber considered to be of particular dietary value by the Inuit. The intake of these Arctic dietary components has the potential to compensate for the limited dermal 25OHD production in Arctic residents[5,12]. However, this does not provide an alternative source of Ca that is sparse in the dietary components that comprise the traditional Inuit diet. Thus, Canadian Inuit and Alaska Natives reported a low Ca intake[13,14], and a low dietary Ca content in local foods in Greenland[15] was speculated to be the cause for low serum Ca in Greenland Inuit[16].

Ca intake has a limited impact on short-term Ca status of an individual as Ca level in serum is maintained within narrow limits by powerful endocrine control mechanisms[17]. These interactive homoeostatic mechanisms may have adapted to short-term low Ca intake, whereas long-term low Ca intake maintains importance for the occurrence of diseases. Thus, low parathyroid hormone (PTH) with hypocalcaemia associates with low bone turnover, infections, IHD and dental enamel hypoplasia[17].

Abbreviations: 25OHD, 25-hydroxyvitamin D; PTH, parathyroid hormone.

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Greenland Inuit have been reported to have a high occurrence of osteoporotic fractures[18], severe infections[19], a distinct rise in the occurrence of IHD[20,21] and dental diseases[22]. These diseases may be related to long-term low Ca intake despite being managed short term by an adaption of the homoeostatic mechanisms.

This led us to explore the associations between Ca, PTH and 25OHD in serum among Greenlanders and non-Greenlanders living in the capital city Nuuk in West Greenland and in the rural Ammassalik district in East Greenland as major players in Ca homoeostasis include PTH and vitamin D.

Methods

Area of investigation, subjects and procedures

We included subjects living in Ammassalik district (65°35'N 38°00'W) in East Greenland or in the capital city Nuuk in West Greenland (64°15'N 51°35'W).

We invited 50- to 69-year-old men and women, Greenlanders (all Inuit) and not Greenlanders (all Caucasian Danes), recorded, selected and living on the address as described in detail previously[7,11]. The places selected for investigation were Nuuk, Tasiilaq and the settlements Tiniteqilaaq, Sermiligaaq, Kulusuk and Kuummiut in Ammassalik district. Only 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 and fifty-three in Kuummiut, and 95 % participated. A Greenlander was defined as an individual born in Greenland with both parents born in Greenland and is hereafter named Inuit.

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and the Commission for Scientific Research in Greenland approved the procedures (reference no. 2010–8). All subjects gave informed written consent in Danish or Greenlandic by participant 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. The physical examination performed included 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 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 at all sites.

Dietary habits

Dietary habits were assessed using an interview-based FFQ. 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, egg and fresh fruit). These were selected based on their contribution to the diet in Greenland[23]. Each food item was categorised into one of six frequency categories from never to daily intake. A frequency score was calculated based on the average number of days per month it was ingested[7,23]. 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 into quintiles – diet group 1: >80 % Inuit food item scores; 2: 60–80 %; 3: 40–60 %; 4: 20–40 %; 5: <20 % Inuit food item scores. The scale was based on high scores for predominantly traditional Inuit food items and low scores for imported food items. Scores were validated by cross-check questions, as well as by the use of iodine as a biomarker of the intake of the iodine-rich traditional Inuit foods[11,24]. The intake of vitamin-D-containing supplements was evaluated from the frequency of intake.

Blood sampling and assays

Venous blood samples were obtained by venepuncture using minimal tourniquet. Whole blood was allowed to clot, spun using a portable centrifuge and serum was separated and stored at −20°C until analysis. Samples were stored on the roof of the nursing stations in the settlements in East Greenland as the temperature was below – 20°C. The bag with samples had to be kept on the roof to be out of reach of sledge dogs.

Ca and albumin were measured using standard laboratory methods (Hitachi 917; Roche Diagnostics Corp.). Intra-/inter-assay CV were 0·9/1·5 % for Ca and 1·5/2·1 % for albumin (information supplied by manufacturer). Approximately 50 % of total serum Ca in blood is bound to proteins, and only the non-bound Ca is biologically active and tightly controlled by hormonal mechanisms. We thus adjusted for individual variations in albumin (adjusted serum Ca (mmol/l) = total serum Ca (mmol/l) – 0·00086 × (650 – serum albumin (μmol/l))). PTH was measured using Immulite automated analyser (Diagnostic Products Corporation) with an overall CV below 7 %. Serum 25OHD levels were analysed by isotope dilution liquid chromatography–tandem MS with inter-assay CV of 8·6 and 9·4 % for $25OHD_2$ and $25OHD_3$[25]. Calibrators traceable to National Institute of Standards and Technology standard reference material (SRM972) were used for external quality assurance (Chromsystems)[25].

Statistics

Results are given as medians and 25th and 75th percentiles. Groups were compared using non-parametric statistics: the χ^2 test for comparison of proportions, the Mann–Whitney U test for comparison of two groups and the Kruskal–Wallis test for comparing several groups. Distributions were tested using the

Kolmogorov–Smirnov test and logarithmic transformation was performed on data not following the Gaussian distribution (Ca and PTH) for further analysis. Bartlett's test was used to test for homogeneity of variance to support description of dispersion by standard deviations or interquartile ranges (IQR). Linear regression models were used with PTH and Ca entered as dependent variable. Explanatory variables entered were ethnic origin, diet group, alcohol intake, smoking habits, sex, age, 25OHD in serum and BMI. PTH was included for investigation of Ca, and Ca was included for investigation of PTH. Diet and origin were investigated in separate models in the multivariate linear regression analysis because of covariance. 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 <0·05 was considered significant.

Results

In all, 1 % of the population of Greenland was invited and 95 % participated. Table 1 lists the characteristics of the participants. Seven non-Inuit had one parent born in Greenland, whereas ninety-four had neither parent born in Greenland. Non-Inuit were mainly skilled labour from Denmark and thus included more men than women ($P<0·001$). This also influenced the age distribution because some leave Greenland at retirement. Alcohol intake was higher among Caucasian Danes and more Inuit were smokers. Hunting and dietary habits differed with geography. Dietary habits differed markedly both between Inuit and Caucasian Danes ($P<0·001$) and among Inuit groups ($P<0·001$). Thus, 22 % of Caucasian Danes reported a food frequency score of 40 % Inuit foods or more, whereas this was 86 % of Inuit in Nuuk and 99 % of Inuit in Tasiilaq and settlements. 25OHD groups are detailed in Table 1, and Table 2 gives

Table 1. Descriptives of participants in the survey of diet and calcium homoeostasis in 50- to 69-year-old residents in East and West Greenland (Numbers and percentages; mean values and standard deviations)

	Non-Inuit†		Inuit in Nuuk		Inuit in Tasiilaq		Inuit in settlements		P*		
	n	%	*n*	%	*n*	%	*n*	%	Inuit *v.* Caucasians	Among all groups	Among Inuit groups
Participants	101	100	150	100	141	100	143	100			
Sex											
Men	80	79·2	70	46·7	80	56·7	79	55·2			
Women	21	20·8	80	53·3	61	43·3	64	44·8	<0·001	<0·001	0·17
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	<0·001	0·81
Smoker‡											
Never	26	25·7	22	14·8	19	13·5	15	10·5			
Past	18	17·8	16	10·7	14	9·9	19	13·3			
Present	57	55·3	111	74·5	108	76·6	109	76·2	<0·001	0·008	0·75
<10	10	9·9	70	47·0	59	41·8	59	41·3			
10–20	31	30·7	35	23·5	44	31·2	45	31·5			
>20	16	15·8	6	4·0	5	3·5	5	3·5			
Alcohol use§											
Never	11	11·0	20	13·9	36	25·9	73	51·0			
0–7 units	45	45·0	72	50·0	52	37·4	21	14·7			
8–14 units	25	25·0	40	27·8	35	25·2	20	14·0			
15–21 units	7	7·0	10	6·9	11	7·9	17	11·9			
>21 units	12	12·0	2	1·4	5	3·6	12	8·4	<0·001	<0·001	<0·001
Greenlandic diet score (%)‖											
>80	2	2·0	43	28·7	93	66·0	103	72·0			
60–80	6	5·9	45	30·0	29	20·6	30	21·0			
40–60	14	13·9	41	27·3	17	12·1	8	5·6			
20–40	41	40·6	17	11·3	1	0·7	2	1·4			
<20	38	37·6	4	2·7	1	0·7	0	0·0	<0·001	<0·001	<0·001
Diet scores											
Mean	−325		−178		−114		−19				
SD	101		168		125		94				
Hunting¶											
Trade	2	2·0	8	5·5	22	15·8	45	31·5			
Leisure	39	38·6	44	30·3	52	37·4	53	37·1			
Rarely	60	59·4	93	64·1	65	46·8	45	31·5	<0·001	<0·001	<0·001
Vitamin D (nM)††											
<20	12	11·9	0	0·0	2	1·4	0	0·0			
<50	69	69·0	23	15·4	37	26·8	37	26·2			
>50	31	31·0	126	84·6	101	73·2	104	73·8	<0·001	<0·001	0·033

* χ^2 Test.
† Including seven participants of mixed origin.
‡ Information missing in one participant in Nuuk.
§ Estimated units of alcohol per week. Information missing in nine (1/6/2/0) participants. Comparison above *v.* below 7 units/week.
‖ Diet groups <20, 20–40 and 40–60 % combined for χ^2 test.
¶ Information missing in seven (0/5/2/0) participants. Trade and leisure groups merged for statistical analysis.
†† Information missing in seven (1/1/3/2) participants. Statistical comparison performed for below *v.* above 50 nM.

the medians and 25, 75 percentiles, in addition to means and standard deviations, of 25OHD, PTH and Ca, total and corrected for individual albumin levels, in the participant groups.

Total serum Ca was lower in Inuit than in Caucasian Danes and did not differ between Inuit groups (Table 2). Albumin adjustment augmented the ethnic difference. In addition to the difference in mean, dispersion of Ca differed with ethnicity, with higher SD and IQR in Inuit compared with Caucasian Danes ($P<0·01$) and no difference between Inuit groups (NS). PTH differed between Inuit and Caucasian Danes, with a higher level in the latter (Table 2). In addition, PTH did not differ between Inuit groups. Dispersion of PTH differed between Inuit and Caucasian Danes ($P<0·01$) and among Inuit groups ($P<0·01$). Serum 25OHD levels differed with ethnicity (Table 2) and between Inuit groups, as did dispersion both with ethnicity ($P=0·01$) and between Inuit groups ($P<0·01$).

Fig. 1 illustrates the distinct ethnic difference in the association between serum 25OHD and PTH in the serum 25OHD insufficiency range. Although PTH rose with low serum 25OHD in Caucasian Danes, this did not occur in Inuit, and PTH differed in the 69/97 Caucasian Danes/Inuit with serum 25OHD <50 nmol/l ($P=0·001$).

Table 3 lists factors important to Ca and PTH in serum as evaluated in crude and adjusted analysis. The factors of main importance to Ca levels were ethnic origin, diet and serum 25OHD after adjusting for also sex, age and PTH. Serum PTH levels were influenced by ethnic origin, diet and serum 25OHD in the adjusted analysis that included also BMI and smoking. As for $P-25$OHD, a main association was seen with diet ($P<0·001$), whereas some association was seen with Ca ($P=0·021$) and PTH ($P=0·007$).

Discussion

Previous findings suggested an ethnic influence on Ca homoeostasis in Inuit compared with Caucasian Danes by a difference in serum Ca[6,16], an influence of ethnicity on PTH[6] and by the fact that ethnic origin modified the influence of diet on serum 25OHD levels[7]. These hints all point to an importance of ethnic origin for Ca homoeostasis. In addition, they are in resonance with the intuitive understanding of an adaption among Arctic residents to an environment low in dietary Ca and possibly vitamin D. Exploring this topic may provide further insight into our understanding of Ca homoeostasis.

The conductor of the Ca homoeostasis orchestra is PTH. Ethnicity, diet and serum 25OHD associated with PTH in our data. The differences in slope were limited, but it is intriguing that the larger beta was seen with ethnicity. The number of subjects with 25OHD in the range of insufficiency differed between Inuit and Caucasians (22·7 %, ninety-seven Inuit; 69 %, sixty-nine Caucasians), but it was clearly sufficient to detect a statistically significant difference in PTH, as well as in Ca. It seems thus that ethnicity could have a major influence on Ca homoeostasis when comparing Caucasians and Inuit. Interestingly, the same accounted for Ca that had the slightly larger beta coefficient for PTH. An influence of ethnic origin on Ca homoeostasis is thus a likely trait in our data. This is in keeping with the findings by Rejnmark *et al.* of lower

Table 2. Calcium, parathyroid hormone (PTH) and vitamin D among Inuit and Caucasians aged 50 to 69 years living in East and West Greenland
(Mean values and standard deviations; medians and 25, 75 percentiles)

	Caucasians†		Inuit‡		Inuit in Nuuk		Inuit in Tasiilaq		Inuit in Settlements		*P**		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Inuit *v.* Caucasians	Among all groups	Among Inuit groups
Number of participants	101		434		150		141		143				
Ca (mmol/l)§	2·31	0·11	2·28	0·14	2·28	0·14	2·27	0·14	2·29	0·13			
Median	2·33		2·29		2·30		2·29		2·29		0·010	0·052	0·46
25, 75 percentiles	2·26, 2·38		2·21, 2·36		2·21, 2·36		2·19, 2·35		2·23, 2·37				
Ca (mmol/l)‖	2·37	0·13	2·31	0·16	2·32	0·17	2·29	0·17	2·33	0·15			
Median	2·38		2·33		2·35		2·31		2·33		0·001	0·002	0·08
25, 75 percentiles	2·31, 2·45		2·24, 2·42		2·24, 2·43		2·20, 2·39		2·24, 2·42				
PTH (pmol/l)	3·2	1·4	2·3	1·0	2·35	1·2	2·34	0·95	2·39	0·94			
Median	2·7		2·2		2·1		2·2		2·2		<0·001	<0·001	0·39
25, 75 percentiles	2·2, 4·1		1·7, 2·7		1·7, 2·7		1·7, 2·7		1·8, 2·9				
25OHD (nmol/l)¶	41	18	67	22	75	25	61	20	62	18			
Median	42		64		72		59		61		<0·001	<0·001	<0·001
25, 75 percentiles	25, 54		51, 81		60, 89		49, 73		50, 72				

* Mann–Whitney test.
† Seven had one and ninety-four had both parents born in Denmark.
‡ All had both parents born in Greenland.
§ Total Ca.
‖ Ca corrected for individual variation in albumin.
¶ 25-hydroxyvitamin D_2+D_3. Information missing in four participants.

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PTH among Inuit in a study comparing forty-three Caucasian Danes in Denmark with Inuit in Denmark and Greenland with a focus on seasonal differences[6]. Despite the lower PTH, they found both higher 1,25-dihydroxyvitamin D and lower Ca in serum among Inuit compared with Caucasian Danes. This conforms to the hypothesis that Inuit has adapted to a low-Ca environment with augmented absorption of dietary Ca from the intestines and promoted Ca fluxes into blood from kidney and bones mediated by the slightly higher 1,25-dihydroxyvitamin D. These findings encourage further study.

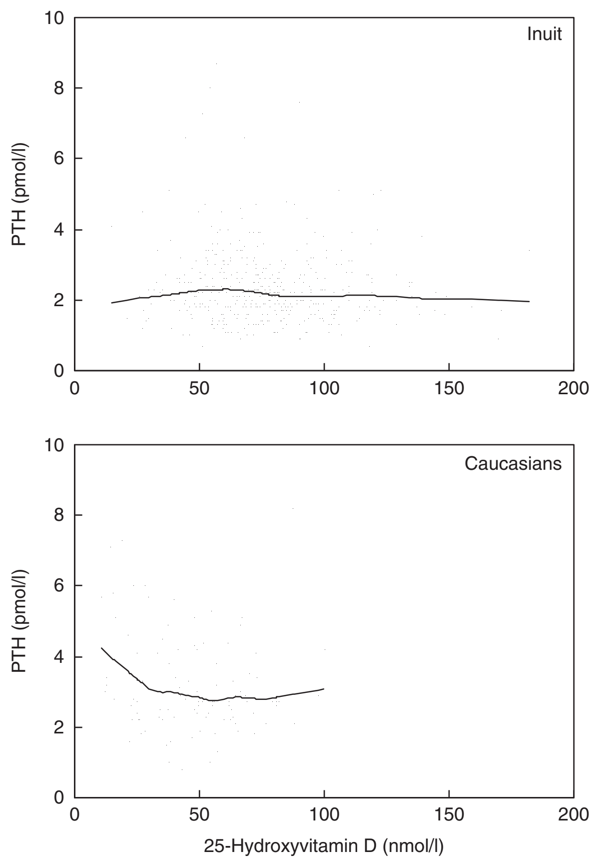

Fig. 1. Association between parathyroid hormone (PTH) and vitamin D differed between individuals of Greenlandic descent (Inuit, upper panel) and migrants (Caucasians, lower panel) living in Greenland.

A number of mechanisms may contribute to the differences with ethnic origin. An altered vitamin-D-binding protein has been demonstrated among Asians compared with other ethnic groups[26]. Inuit are of Asian descent and they could be speculated to have different levels of vitamin-D-binding protein. The latter may influence 25OHD metabolism[27], and 25OHD half-life associated with vitamin-D-binding protein with ethnic differences between Gambian subjects and Caucasians[28]. However, differences in vitamin-D-binding protein levels were more marked within Inuit groups than with ethnic origin in the previous study[6]. The group size was limited in that study but a marked difference would have been detected. Hence, this mechanism is less likely, as vitamin-D-binding protein levels were similar in Inuit and Caucasian Danes.

An altered 1-α-hydroxylase activity in Inuit compared with Caucasian Danes is another mechanism to consider. Higher levels of 1,25-dihydroxyvitamin D in Inuit compared with Caucasian Danes was demonstrated despite lower levels of serum 25OHD[6]. The higher 1,25-dihydroxyvitamin D augments the intestinal absorption of Ca and suppresses PTH secretion. This is in keeping with our finding of a lower PTH among Inuit than Caucasian Danes[6]. Nevertheless, this association needs further evaluation as other mechanisms may influence PTH. These include differences in PTH activity, PTH-related proteins influencing the PTH receptor and a genetic variant in Inuit. The latter would be in line with the genetic signature of adaptation to a high-fat diet demonstrated recently[29]. Similar mechanisms could be speculated to be at play with adaptation to a low-Ca diet. However, a number of

Table 3. Factors associated with calcium and parathyroid hormone (PTH) in 50- to 69-year-old residents in Greenland

	Ca*				PTH			
	Univariate model		Multivariate model†		Univariate model		Multivariate model†	
	β‡	*P*	β‡	*P*	β‡	*P*	β‡	*P*
Ca*					0·02	NS	−0·05	NS
PTH	0·02	NS	−0·04	NS				
25OHD$_2$ and D$_3$	0·10	0·018	0·15	0·001	−0·21	<0·001	−0·17	<0·001
Ethnicity	0·13	0·004	0·22	<0·001	0·28	<0·001	0·27	<0·001
Age (years)	−0·08	0·061	0·00	NS	−0·01	NS	0·06	NS
Sex	0·01	NS	0·10	0·036	−0·07	0·10	−0·01	NS
BMI (kg/m^2)	0·10	0·021	0·05	NS	0·02	NS	0·01	NS
Diet§	0·14	0·002	0·19	<0·001	0·19	<0·001	0·20	<0·001
Alcohol	−0·02	NS	−0·04	NS	0·01	NS	−0·01	NS
Smoker	0·01	NS	0·04	NS	−0·03	NS	−0·02	NS

25OHD, 25-hydroxyvitamin D.
NS $P > 0·1$.
* Ca corrected for individual variation in albumin.
† Dependent variables were serum Ca/PTH and explanatory variables were age, sex, serum PTH/Ca, alcohol intake, diet and ethnicity. Diet and origin were tested in separate models owing to collinearity.
‡ β (Regression) coefficients were Inuit/non-Inuit; advancing age; men/women; rising BMI; decreasing Inuit diet; increasing alcohol intake; and smoking with groups as given in Table 1.
§ Diet based on diet groups calculated from the frequency of intake of seven Inuit and seven imported food items – diet group 1: 80 %; 2: 60–80 %; 3: 40–60 %; 4: 20–40 %; 5: 0–20 % Inuit food frequency scores.

physiologic factors may also influence PTH, including smoking and obesity.

Body build differs between Inuit and Caucasians as Inuit have shorter limbs relative to the torso[30,31] and they may present with higher BMI for the same degree of metabolic disturbances[32]. These ethnic peculiarities did not influence PTH as evaluated in the adjusted comparisons in our data.

Smoking rates are high in Greenland[33,34], and about 75 % of Inuit participants in our study were present smokers. The relatively high rate of 56 % smokers among Caucasians was still lower than among Inuit. Yet, smoking did not influence PTH in our data.

The lower Ca and PTH in serum in Inuit compared with Caucasians has the potential to influence bones and the risk for osteoporosis. Available data suggest no difference in BMD between Inuit and Caucasian Danes[35], similar fracture rates[18] and similar impact of risk factors for osteoporosis[34]. Thus, the limited data available do not suggest a difference in the occurrence of bone diseases between Inuit and Caucasian Danes. However, vitamin D plays a pivotal role in skeletal health[1,2], and sufficient 25OHD levels in Inuit[7,36] may contribute to this finding. 25OHD is ample in the traditional Inuit foods that comprise mainly marine mammals and fish in addition to caribou and birds[36,23], but ethnicity had an impact on the influence of diet on serum 25OHD levels[7]. We included only subjects aged 50 through 69 years. This might underestimate the impact of the transition away from traditional foods as older Inuit have a higher intake of traditional Inuit foods[11,37]. Consequently, it may be speculated that the dietary transition in Arctic societies poses a particular risk for skeletal diseases among Inuit. This encourages attention to the influence of dietary transition on bone metabolism and diseases.

The older age group included contributed to a high participation rate of 95 % in this population-based exploratory survey, which supports the validity of the findings. This is further supported by the inclusion of populations at the extremes of transition of societies in Greenland from the capital city Nuuk in West Greenland to remote settlements in East Greenland. We did not measure 1,25-hydroxylase activity, vitamin-D-binding protein, PTH-related protein or further measures of Ca homoeostasis. We recommend this for future studies of influence of ethnic origin on Ca homoeostasis.

An influence of ethnic origin has been debated in relation to body build[30], bone mineral density[35], bone metabolism[36,38], renal function[33] and lipid metabolism[29]. Although differences have been demonstrated[29,30,35,38,39], the cause for such differences has been rather a question of filtering out environmental factors to settle whether genetic factors are at play. We conducted multivariate analysis to adjust for relevant environmental factors. However, the importance of genetics remains to be determined.

In conclusion, we found different Ca and PTH levels in serum in Inuit and Caucasian Danes. A rise in PTH was seen with low serum 25OHD levels in Caucasian Danes but not in Inuit, and ethnic origin was a major determinant of PTH and Ca in our data in addition to diet and P–25OHD. The difference in serum Ca is indicative of an influence of ethnicity on Ca homoeostasis in view of the powerful, interactive homoeostatic mechanisms to maintain serum Ca within narrow limits. This is further supported by the ethnic differences in PTH level and in PTH response to low 25OHD. Recommendations are to follow up on Arctic populations to assess the impact of transition in dietary habits on Ca homoeostasis and skeletal health, and to evaluate mechanisms underlying the ethnic influence on Ca homoeostasis.

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The authors declare that there are no conflicts of interest.

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