DIABETES AMONG INUIT MIGRANTS IN DENMARK

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ABSTRACT

Objectives. The study aimed to estimate the prevalence of diabetes and impaired glucose intolerance (IGT) among Inuit migrants living in Denmark, and to compare with findings from Greenland. Further, we analyzed determinants for diabetes and impaired glucose metabolism.
Study design. Cross-sectional, population–based epidemiological study.
Methods. This cross-sectional study included randomly selected Inuit migrants in Denmark aged 34 years and above. Diabetes and IGT were diagnosed using the oral glucose tolerance test. Body mass index (BMI) and waist circumference were measured, and blood samples were taken from each subject. Socio-demographic characteristics were investigated using a questionnaire. For comparison, data from the Greenland Population Study were used (n = 917).
Results. Of 506 eligible subjects, 256 (51%) participated. Twenty-six subjects had diabetes (10.2%) and twenty-eight had IGT (10.9%). Of those with diabetes, 64% had not been previously diagnosed. The prevalences of diabetes and IGT were not significantly different from those among Inuit in Greenland. Significant predictors of diabetes and impaired glucose metabolism (IGM) were found to be age, waist circumference and physical inactivity. The association between waist circumference and diabetes was significantly stronger among Inuit migrants in Denmark than among Inuit in Greenland.
Conclusions. The prevalence of diabetes is high among the Inuit migrants in Denmark. However, unlike that reported in most studies, the prevalence was not significantly higher in the migrant population compared with the population of origin.
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Keywords: OGTT, oral glucose tolerance test, BMI, body mass index, IGM, impaired glucose metabolism

INTRODUCTION

Studies of the Inuit prior to the 1980s have reported a lower prevalence of diabetes compared to Northern European populations (1). However, we have recently reported a surprisingly high prevalence of diabetes and IGT among the Inuit of Greenland. Amomg men, the prevalences of diabetes and IGT among participants over 34 years old were 10.8% and 9.4%, respectively, and 8.8% and 14.1% among women (2). Thus, the Greenlandic population seems to have undergone, or to be undergoing, a transition from low to high prevalence of diabetes.

In our previous study, three groups of Greenlanders living under different conditions in Greenland were studied. One group lived in villages in a hunting district (Uummannaq), another in a small town (Qasigiannguit), while a random sample of the population living in the capital (Nuuk) comprised the third group. The three areas were chosen to represent increasing degrees of acculturation, or westernization, with the hunting villages representing the most traditional lifestyle and the capital the most westernized lifestyle. The assumption was that the survey would find a geographical manifestation of the transition process, with a gradient of increasing prevalence, going from the least, to the most westernized subpopulations. Surprisingly, the results did not show such a gradient – the prevalence of diabetes proved to be highest in the villages and lowest in the intermediate size town (2).

One possible explanation for this finding is that the lifestyle no longer varies sufficiently within Greenland to yield a gradient – the changes that have caused the transition may have already occurred across all the subpopulations studied.

Ethnic Greenlanders, including those living in Denmark, are genetically Inuit (Eskimos), with a substantial admixture of European, mainly Danish, genes. They are closely related to the Inuit and Yupik in Canada, Alaska and Siberia. Around 7000 ethnic Greenlanders live in Denmark. There are three major subgroups in this population. One of these is made up of women who have married Danes working in Greenland. Others are themselves children of marriages between Greenlanders and Danes, and have moved to Denmark with their parents at a young age. Finally, some Greenlanders move to Denmark for educational purposes, and may end up staying permanently. Only 20% have neither a Danish parent, nor a Danish spouse, and there is a preponderance of women in the Inuit population in Denmark (3).

This group of migrants is well integrated into the Danish society, and has a lifestyle similar to that of the general population of a Western industrialized country. Thus, the Inuit migrants are exposed to a lifestyle that differs considerably from that in Greenland. This offers a unique opportunity to study the effects of westernization, and to study the factors that could contribute to the transition from low to high prevalence of glucose intolerance. The aims of this study were to assess the prevalences of IGT and diabetes among ethnic Greenlanders living in Denmark, to compare them with findings from Greenland, and to identify determinants for IGT and diabetes. Our hypothesis was that the lifestyle acquired through migration to Denmark would increase the risk of diabetes and, thus, cause a higher prevalence among the migrants than among the residents of Greenland.

MATERIAL AND METHODS

Participants

Greenlanders living in Denmark were initially identified through the Central Population Register as those persons born in Greenland but presently living in Denmark. A random sample of those living in the eastern part of Denmark was drawn from the total population over the age of 34 years. Of the sampled persons, only those with at least one Inuit parent were included in the study. Data were collected between March and September 2002. Participants (n=506) were invited by mail.

Data from the Greenland population study were used for comparison. The Greenland population study was a population-based, randomized survey carried out in Greenland from 1999-2001. 917 persons aged 35 years and above participated in the study in Greenland (4).

Verbal and written consent was obtained from all participants. Full approval for the study was obtained from the Ethics Review Committee in Denmark.

Survey procedure

The participants attended the clinic between 08:00 and 10:00 h, after an overnight fast. A 2-h standard 75-g oral glucose tolerance test was performed. Height was measured and the participants were weighed on a standard clinical balance beam scale wearing undergarments. BMI was calculated. The waist circumference of the standing participant was measured midway between the iliac crest and the costal margin.

Blood samples were placed immediately on ice and spun at 4°C within 30 min of sampling. Plasma glucose was determined by the hexokinase/G6P-DH method, using a Hitachi 912 system in the laboratory of the Steno Diabetes Center.

For participants with a known history of diabetes, fasting glucose was measured without an OGGT.

Glucose tolerance was classified according to World Health Organization criteria (5). Fasting plasma glucose ≥ 7.0 mmol/l and/or 2-h plasma glucose ≥ 11.1 mmol/l were taken to indicate diabetes, and IGT was defined as a fasting plasma glucose level < 7.0 mmol/l and 2-h plasma glucose ≥ 7.8 and < 11.1 mmol/l.

The details of the survey procedure in Greenland have been published elsewhere (4). Plasma samples from Greenland and Denmark were analyzed in the same laboratory, using identical methods and clinical procedures.

Interviews and questionnaires

Data were collected by structured interviews and self-administered questionnaires. Information on age, sex, former places of residence in Greenland and duration of stay in Denmark was recorded, as were family histories of diseases. Inuit blood quantum was estimated from questions on the ethnicity of the four grandparents and, if this information was missing, of the parents. It was recorded as full Inuit heritage (all grandparents Inuit), or partly Inuit heritage.

Participants completed a food frequency questionnaire including questions on the consumption of seal, whale, fish, fresh fruit and vegetables, egg and various dairy products. The questionnaire also contained questions on the consumption of alcohol. The frequency of alcohol consumption was reported. Participants were classified as current smokers, or non-smokers, the latter including past smokers.

Highest educational grade completed and current employment was recorded.

Physical activity levels during leisure-time, summer and winter were measured using a standardised questionnaire (6), where information on leisure-time physical activity comprised five categories: 1) sedentary; 2) light; 3) physical activity less than four hours per week; 4) physical active at least four hours per week; and 5) heavy activity several times per week. Due to the small group sizes, it was recoded on a three-point scale: sedentary (1); moderate (2 and 3); and heavy physical activity (4 and 5)

Data analysis and statistics

Analyses were performed using SPSS 11.0 and, for logistic regression models, SAS 8.2. The direct method was used to age- and gender-standardize the prevalence of diabetes among Greenlanders and migrants, respectively, to the total survey population. Inter-group comparisons were performed using Pearson's Chi^2-test for categorical variables and Student's t test for continuous variables. To evaluate associations with glucose tolerance status, two categorical variables were produced to reflect the glucose tolerance status as follows: 1) diabetes versus normal glucose tolerance, and 2) Impaired glucose metabolism (diabetes + IGT) versus normal glucose tolerance. Multiple logistic regression analyses were performed to assess the association of the following risk factors with the glucose tolerance status among migrants and non-migrants: gender, age, waist circumference, physical activity and family history of diabetes. Waist circumference was chosen for the measurement of obesity, because this anthropometrical measurement is suggested to be the best marker of intra-abdominal fat (7). To test whether the association between the glucose intolerance status and risk factors differed between the two countries, we used an interaction term between country of residence and each of the risk factors.

RESULTS

A total of 506 Inuit migrants in Denmark were invited to participate in the study. Of those, 256 attended the study (50.6%). The mean age of the participants was 45 (range 34-76), compared to 49 (range 35-86) among participants in Greenland ($p = 0.0002$). Of the participants in Denmark 72.2% were women, compared to 56.1% in Greenland ($p < 0.0001$). Ninety-six percent had lived in Denmark for 3 years or more (average 28.2 years).

All participants were classified with respect to glucose tolerance. Twenty-six subjects had diabetes (10.2%, 95% CI 6.5-13.9%). The age-standardized prevalence of diabetes was 10.8% among women and 7.1% among men ($p = 0.04$). There was no difference in the age- and gender-standardized prevalences of diabetes between the two Inuit populations (9.8% vs. 9.6%, $p = 0.92$).

Of those with diabetes, 16 (64%) were not previously aware of their diabetic status compared with 70% in Greenland ($p = 0.14$). Among the migrants in Denmark, 19% with diabetes were diagnosed solely on the basis of fasting glucose, compared with 53% of the diabetics in Greenland ($p = 0.03$), and 44% of the migrants were diagnosed solely on the basis of elevated 2-h glucose values compared with 19% in Greenland ($p = 0.02$).

Twenty-eight subjects had IGT (10.9%, 95% CI 7.1-14.7%). The age-standardized prevalence of IGT was 12.4% among women and 7.0% among men ($p = 0.03$). The age- and gender-standardized prevalences of IGT were not significantly different in the two Inuit populations (10.1% vs. 12.2%, $p = 0.51$). The prevalences of diabetes and IGT increased with age among both men and women ($p < 0.0001$; figure 1).

The two population groups differed significantly with regard to a number of biological, behavioral and socio-economic factors (Table I). Almost half of the migrants were of mixed heritage. On average, the migrants had lower mean levels of BMI and waist circumference than the residents of Greenland. Consumption of seal and fish was very low among the migrants, while the consumption of fresh fruit was low among the participants in Greenland. Alcohol consumption was more frequent among the migrants. Conversely, there were fewer smokers among the migrants than among the residents of Greenland. No significant difference was found in the distribution between categories of physical activity. Finally, the length of school education received was generally shorter among the residents of Greenland than among the migrants. In Greenland, 62% had attended school for eight years or less, compared to 21% of the migrants.

Two logistic regression models were constructed, with diabetes and impaired glucose metabolism as dependent variables for each of the two countries. Gender, age, waist circumference, physical activity and family history of diabetes were included as explanatory variables (Table II).

In both Denmark and Greenland, age and waist circumference were significantly associated with diabetes. Physical activity was negatively associated with diabetes, but, although consistent, the association was not statistically significant in Greenland. The same variables were associated with impaired glucose metabolism in both countries. In the multivariate model, gender and ethnicity were not statistically significantly associated with diabetes or impaired glucose metabolism, in either Denmark, or Greenland. There was a significant difference in the association between waist circumference and diabetes in the two countries: the association was stronger among

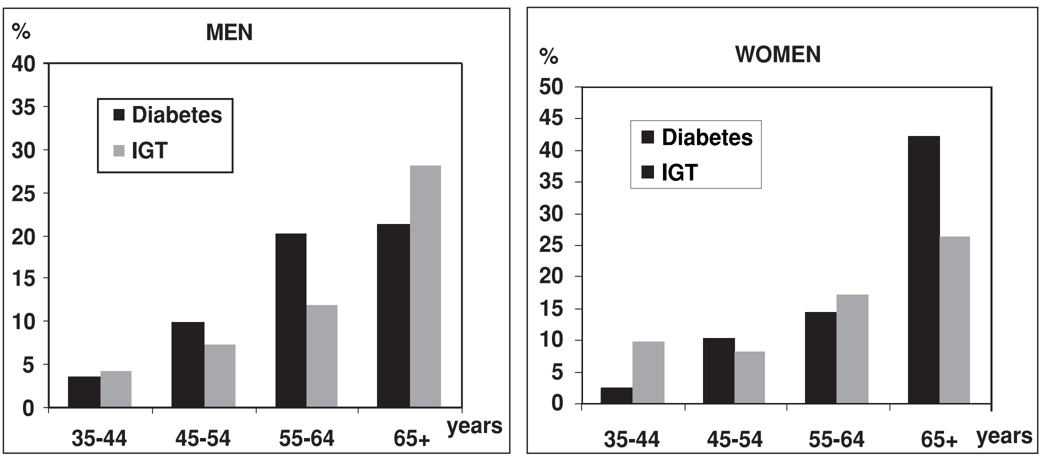

Figure 1. Age-specific prevalence of diabetes and impaired glucose tolerance (IGT) among migrant men and women in Denmark.

Table I. Distribution of basic variables among Inuit migrants in Denmark and Inuit in Greenland.

		Migrants mean (SD)	Greenland mean (SD)	p
Continuous variables				
	Age (years)	46	49	0.0003
	BMI (kg/m^2)	25.8 (4.5)	26.7 (5.2)	0.009
	Waist circumference (cm)	86 (12)	90 (13)	< 0.001
Categorical variables		%	%	
Gender	Male	28	44	
	Female	72	56	< 0.001
Ethnicity	75% or less Inuit heritage	49	12	
	Full Inuit heritage	51	88	< 0.001
Family history of diabetes	No	85	89	
	Yes	15	11	0.053
Physical activity	Sedentary	7	12	
	Moderate activity	76	71	
	Heavy activity	17	17	0.110
Consumption of seal or fish	Less than weekly	99	55	
	Weekly	1	45	< 0.001
Consumption of fresh fruit	Less than daily	33	74	
	Daily	67	26	< 0.001
Smoking status	Current smoker	55	66	
	Non-smoker	45	34	0.001
Alcohol consumption	>3 times per week	25	5	
	1-2 times per week	30	21	
	1-3 times per month	20	24	
	Less than monthly or never	25	50	< 0.001
Education	8 years or less	21	62	
	9-12 years	59	34	
	High school or more	19	4	< 0.001

Table II. Determinants of diabetes and impaired glucose metabolism (Diabetes + IGT) in two multiple logistic regression models. P-values are for the hypothesis of no difference between the OR's.

Dependent variable		Denmark OR (95% CI)	Greenland OR (95% CI)	p
Diabetes vs. normal glucose tolerance (NGT)				
Age	per 10 years	1.63 (1.04-2.71)	1.46 (1.20-1.79)	
		p = 0.03	*p < 0.0001*	n.s
Sex	women	1	1	
	men	0.31 (0.07-1.28)	1.02 (0.64-1.64)	
		p = 0.10	*p = 0.89*	n..s
Waist circumference	per 5 cm	1.91 (1.54-2.51)	1.24 (1.14-1.35)	
		p < 0.0001	*p < 0.0001*	< 0.0001
Ethnicity	Full Inuit heritage	1.85 (0.57-5.95)	0.80 (0.42-1.53)	
	Mixed Inuit heritage	1	1	
		p = 0.17	*p = 0.62*	n.s.
Physical activity	Sedentary	1	1	
	Moderate activity 0.19	(0.04-0.90)	0.64 (0.27-1.51)	
	High activity	0.16 (0.01-2.03)	0.65 (0.35-1.22)	
		p = 0.04	*p = 0.48*	n.s.
Impaired glucose metabolism vs. normal glucose tolerance (NGT)				
Age	per 10 years	1.99 (1.38-2.86)	1.76 (1.50-2.07)	
		p < 0.0001	*p < 0.0001*	n.s.
Sex	women	1	1	
	men	0.62 (0.25-1.53)	0.73 (0.50-1.07)	
		p = 0.29	*p = 0.11*	n.s
Waist circumference	per 5 cm	1.29 (1.10-1.51)	1.23 (1.26-1.32)	
		p < 0.0001	*p < 0.0001*	n.s.
Ethnicity	Full Inuit	1.45 (0.68-3.13)	0.82 (0.50-1.36)	
	Mixed Inuit heritage	1	1	
		p = 0.38	*p = 0.64*	n.s.
Physical activity	Sedentary	1	1	
	Moderate activity	0.88 (0.25-3.17)	0.60 (0.36-0.99)	
	High activity	0.12 (0.01-1.24)	0.51 (0.25-1.01)	
		p = 0.09	*p = 0.20*	n.s.

migrants in Denmark. The logistic regression analyses were repeated using BMI instead of waist circumference as the explanatory variable (data not shown). The same variables were associated with diabetes and impaired glucose metabolism and, for BMI, the association with glucose abnormalities was significantly modified by country of residence.

DISCUSSION

The prevalence of diabetes and impaired glucose tolerance was high among Inuit migrants in Denmark compared with a general Danish population (8). This study did not find a significantly higher prevalence of IGT or diabetes among migrants than among residents of Greenland. A high proportion of individuals with diabetes were unaware of their disease.

The fact that significantly more participants in Denmark were diagnosed on the basis of elevated 2-h glucose levels may be attributable to a higher degree of insulin resistance among the migrants, rather than insulin deficiency, although controversy continues over the relative contributions of insulin sensitivity and insulin deficiency in glucose intolerance (9-12).

Other migrant populations have been studied with the aim of comparing the prevalence of diabetes with that in their countries of origin. Studies of Japanese migrants in Hawaii (13), Tokelau Polynesians in New Zealand (14), Indian and Chinese migrants in Mauritius (15) and Caribbean migrants in the UK (16), all found a significantly higher prevalence in the migrant populations, compared to the respective countries of origin. It appears that, in many populations, there is a marked effect of migration to more industrialized societies. The hypothesis has been put forth that, in populations that have lived under “feast or famine” conditions, individuals with a tendency towards insulin resistance, and a consequent increased ability to store fat, have had the best chances of survival. This “thrifty genotype” would then manifest itself as obesity and diabetes when the population is exposed to the environment of plenty in a westernized, industrialized society (17). Considering this, our findings might be seen as all the more surprising. However, when looking at other aspects of the metabolic syndrome, there is evidence that the changes that occur with westernization in the Inuit population do not follow expected patterns.

Thus, in a previously published study, Inuit migrants in Denmark proved to be less obese than the residents of Greenland (18). The effect was most pronounced for women.

The results were also surprising when studying serum lipids in relation to westernization and migration among the Greenland Inuit. Female Inuit migrants in Denmark had significantly higher HDL levels than those living in Greenland and LDL levels similar to those of the least westernized women in Greenland. For male migrants, HDL levels were similar to those of the least westernized men in Greenland, while there was no difference for LDL (19).

It would appear that there are several stages of westernization: early stages that cause an increasing risk of diabetes and other components of the metabolic syndrome, and later stages that may cause reduction of the risk relative to the early stages. The population of Greenland is known originally to have had a low prevalence of diabetes, so a transition from low to high prevalence must have occurred. This would then represent the early stages of westernization. When comparing with migrants in Denmark, we are comparing with a population that has changed its lifestyle further, i.e. become more westernized and, apparently, these further changes do not increase the risk of diabetes, and may even reduce the risk of other components of the metabolic syndrome. Other factors related to urbanization and migration, such as higher socio-economic status and a higher level of education, are likely to be responsible for the relationship observed between westernization and components of the metabolic syndrome in Inuit populations. Thus, it appears that Greenland Inuit follow the pattern usually observed in industrialized countries with the highest risk of diabetes in the lower socio-economic groups. However, further studies in a larger group of migrants are needed to allow more detailed analyses.

Due to the low response rate among the migrants, a selection bias cannot be excluded. Any differences between Greenland and Denmark in the factors that made people attend, or not, would bias results and make comparison less valid. In Greenland, the oral glucose tolerance test was taken as part of a wider health examination. In Denmark, the study was presented to potential participants as an examination specifically to identify diabetes and cardiovascular risk factors, and only these aspects of health were examined. Those who already knew they had diabetes may have been more likely not to attend, causing an over-sampling of non-diabetics in the migrant population.

The surveys in Greenland and Denmark were carried out in 1999-2001 and 2002, respectively. Any time trend in the prevalence of diabetes affecting both Greenland and Denmark would have introduced bias. Since the global time trend for diabetes is that of an increase, this would tend to inflate the prevalence among the migrants relative to that in Greenland.

Aside from bias deriving from the collection of data, migrant studies share a common problem of interpretation, stemming from the fact that migration itself is a selective process. People migrate for social, economic, or health-related reasons, among others. Thus, the migrants do not constitute a representative sample of the population of origin. This means that any interpretation regarding the effect of migration to a new environment, based on the comparison of the two populations, must be made with caution.

Various risk factors were included as confounders in the logistic regression models. Age is a well-known risk factor for diabetes and IGM, and was confirmed as such in this study. Obesity, as measured by waist circumference, was a risk factor for both IGM and diabetes. However, there was a significant difference in the effect of waist circumference on diabetes in Denmark and Greenland. It is well known that the association between obesity and cardiovascular risk factors differs across populations, a finding that has mainly been attributed to genetic differences (20,21). A differential impact of obesity on diabetes in two Inuit populations living under different conditions indicates a significant influence of environmental factors on the association between obesity and cardiovascular disease.

Lack of physical activity was also a strong predictor for the development of diabetes and IGT in other studies (22). Physical inactivity showed an independent association with prevalence of IGM and diabetes, although the association was not statistically significant for diabetes in Greenland and for IGM in Denmark. The lack of a statistically significant effect may be a result of the use of a questionnaire developed and validated in a white population (6). The focus on leisure-time physical activity, rather than total activity, may be less useful in Inuit populations, especially in Greenland, where leisure time and occupation time are not necessarily clearly separated, and organized sports are not always available. Furthermore, it is well established that self-report data on physical activity are less reliable and valid than direct measures of physical activity (23). So far, no questionnaire has been developed to assess physical activities in Inuit communities, and the best way to measure physical activity in epidemiological studies in arctic populations has yet to be determined.

One secondary aim of this study was to extend the survey of the Greenland Inuit to include a population with more individuals of mixed heritage. Any effect of the quantum of Inuit blood on the risk of IGT or diabetes would point towards a specific genetic component in the aetiology of these conditions in this population. We found no such significant effect, either in the univariate analyses, or in the logistic regression models. However, it may still be possible to find a genetic component, if more precise measures of genetic Inuit heritage, such as DNA markers, are used.

Our conclusion is that diabetes and impaired glucose tolerance are no longer rare conditions among the Inuit, and, contrary to our initial hypothesis, the prevalence does not increase with migration. Westernization and migration are complex processes, and future studies should focus on behavioral factors associated with modernization, including socio-economic factors and motivational factors associated with migration. Our results underline the need for increased awareness of diabetes, and for intervention against diabetes and similar lifestyle-related diseases in Inuit populations.

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