Short Communication

Type 2 diabetes among farmers and rural and urban referents: cumulative incidence over 20 years and risk factors in a prospective cohort study

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Background: Few studies have examined the risk of type 2 diabetes in various occupational groups. Farmers in Sweden have a low risk of coronary heart disease, but less is known about diabetes. Objective: To analyze the cumulative incidence and relative risk of type 2 diabetes among farmers and referents taking lifestyle factors and components of the metabolic syndrome into account. Methods: In a longitudinal observational cohort study we followed 1,220 farmers, 1,130 rural non-farmer referents and 1,219 urban referents over 20 years. Outcomes were generated from national registers and from two surveys 12 years apart. Baseline data were assessed at the first survey conducted in 1990-91. Results: Farmers had a significantly lower risk of all diabetes compared with urban and rural referents (p<0.05). A total of 91 farmers (8.4%) and 102 non-farming rural referents (11.5%) were identified with type 2 diabetes over the 20 year study period (OR=0.70; 95% CI 0.52-0.95). Fractional analyses of lifestyle factors and components of the metabolic syndrome showed that the low risk of type 2 diabetes among farmers was explained in terms of physical activity and meal quality. Farmers had significantly higher physical capacity (p<0.001) and scored higher in a meal quality index than rural referents (p<0.001). Conclusions: The prevalence of type 2 diabetes was significantly lower among farmers. The low relative risk was explained by high physical activity and better meal quality, indicating that farmers' lifestyles and their work environment are health-promoting.

Key Words: type 2 diabetes, farmers, lifestyle, physical activity, meal quality

INTRODUCTION

The escalating prevalence of type 2 diabetes (T2D) has become an alarming public health issue worldwide. T2D is related to obesity and other components of the metabolic syndrome and is a significantly lifestyle-generated condition.[1] The scene may differ from country to country and in selected subpopulations.

Few studies have analysed the risk and frequency of diabetes in different occupational groups. One Polish study reports high risk of diabetes among road transport drivers,[2] and in Japan, fire fighters and policemen are at increased risk of T2D.[3] In both studies the risk was related to high BMI levels. Blue collar occupations were found to be associated with a high prevalence of diabetes mellitus in another Japanese study.[4]

Previous studies of Swedish farmers and farmers in other countries have shown a general low morbidity risk and a significantly low risk of cardiovascular disorders.[5-8] This low risk is partly related to lifestyle characteristics,[9,10] and a similar pattern can be supposed for T2D. Farmers might have a somewhat more favourable lifestyle, which may impact the diabetes risk in this occupational group and in rural populations in general.

A number of studies have documented significant and strong associations between physical inactivity, unsatisfactory dietary habits, smoking and T2D.[1,11,12] Alcohol consumption and psychological conditions also have an association with the T2D risk.[13,14] Food choices are of major interest in this context, but not only the components of the diet, also eating habits, design of the meals, etc., may be of interest.[15]

Lifestyle factors are related to T2D via a number of incompletely understood mechanisms. Some operate as mediators and are defined as components of the metabolic syndrome. This syndrome is mostly defined as a cluster of overweight/obesity, dyslipidemia, high blood pressure and insulin resistance.[16]

The aim of this study was to analyze the risk of T2D among farmers and rural and urban referents in Sweden and to analyze lifestyle factors impacting the risk.

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METHODS

Study population

A population-based observational prospective cohort study with farmers, rural non-farmer referents and urban referents was established in 1989 with the intention of studying health promoting factors related to farming and lifestyle. All male farmers born between 1930 and 1949 in nine rural municipalities in Sweden were identified from the Swedish National Farm Register. The areas were chosen with consideration to known east-west and north-south cardiovascular disease gradients in the Swedish population and to represent a variety of farm types and geographical variation across the country.[17] Farmers were defined as men who owned or rented farms and who spent at least 25 hours per week farming. The occupational activity was checked with local representatives of the Federation of Swedish Farmers. Farm labourers were not included. For each farmer, one rural referent, matched for age, sex and residential area was sampled from the National Population Register. The rural referents were to be occupationally active but not in farming according to the most recent census. Owing to limited non-farming populations in some of the districts included, the non-farmers were somewhat fewer than the farmers. Furthermore, a group of urban referents, likewise matched for age and sex, was sampled from a medium sized city (30,000-100,000 inhabitants) in the same counties.

Altogether 1,220 farmers, 1,130 rural non-farmers and 1,219 urban referents were eligible and included in the cohort. The farmers and the rural referents (n=2,350) but not the urban referents were invited for an extensive health survey including questionnaires, interviews, physical examinations and laboratory tests 1990-91. The participation rate was 75.8% with 1,782 men attending the baseline survey.[10,18,19] A second survey was performed in 2002-03 and the same individuals were invited when still available. At this time 67.6% of the base population or 72.1% of the available population attended the survey. Altogether 1,963 individuals participated at least once (83.5% of the study population) (Table 1). The entire study population has been followed in national registers.

The study has been approved by the Research Ethics Committee at the Karolinska Institute in Stockholm, Sweden and by the Regional Ethics Board, Uppsala, Sweden. All men who participated in the health surveys gave their informed consent.

Outcomes

Number of fatalities and causes of death from 1989 through 2009 were obtained from the National Cause of Death Register. Diagnoses were according to the International Classification of Diseases (ICD), 9th edition, Swedish version from 1989 through 1996 and 10th edition, Swedish version from 1997 through 2009.[20, 21]

Diagnoses for admissions to hospitals for the years 1989-2009 were obtained from the hospital patient register, which registers all hospital admissions in Sweden with main diagnosis and up to seven additional diagnoses. We used all available diagnoses and counted the number of individuals who were diagnosed with diabetes at least once. Diabetes was defined as ICD-9 code 250 and ICD-10 codes E10-E14.

Diagnoses for outpatients were retrieved from the patient register, which registers all outpatients at hospitals in Sweden for 2001-09. Diagnoses were retrieved and patients included in the same way as for the Hospital Patient Register.

The surveys included structural and elaborated interviews concerning previous health problems and contacts with health care suppliers as well as current prescriptions of drugs including insulin. Individuals with diabetes taking insulin identified at the 1990-91 survey were regarded as type 1 diabetics and were excluded from further analyses. Individuals with diabetes not taking insulin in 1990-91 as well as all individuals diagnosed with diabetes during follow-up were regarded as having T2D.

Lifestyle

The lifestyle factors included in this study were physical activity, meal quality, smoking, alcohol consumption and psychological stress. Physical activity was operationalized as physical work capacity, determined using a submaximal work test on a bicycle ergometer at the baseline survey.[22]

The baseline survey included a meal quality index, which estimates the daily schedule of meals and the main composition of every meal during an ordinary day. The meal data was assessed in a structured interview by a physician with a structured form at hand. The day was split into six periods of three hours each from early morning to late evening and the participant was asked about what kind of food he consumed during each three-hour period. Just something to drink generated one point and a full cooked meal generated 5 points. The points were summarized and the sum was regarded as a meal quality index (Table 2).

Smoking habits were also assessed in interviews at baseline and for the current analysis dichotomized as current daily smoking versus no smoking. Alcohol consumption was likewise assessed in a standardized interview and recorded as total amount of consumed pure alcohol over a week. Stress was operationalized as experienced demand at work and was assessed by the Karasek-Theorell Demand-Control questionnaire answered by the participants on site at the baseline survey.[23]

Metabolic measurements at baseline

The waist/hip ratio was calculated after measuring the waist and hip using a standard tape measure.

Blood pressure was measured twice with mechanical blood pressure equipment (Trim line LIC®) after five minutes of supine rest, and the average recorded. The diastolic blood pressure was used in the analysis.

Non-fasting blood samples were drawn, centrifuged, and refrigerated at 4ºC at the examination site and all samples were transported to the same laboratory in Uppsala for analyse within three days. The serum level of triglycerides was included in the analysis.

Statistical analysis

Analyzed outcome data in this study was generated from several national registers and from two surveys. The1990-91 survey was the baseline. Those who took part only in the second survey in 2002-03 generated no base line data.

Urban referents only generated register data. The internal non-response rate was very low for most items (less than 2%). Physical work capacity testing had more dropouts owing to clinical precautions in permitting testing, and the missing rate for the Karasek-Theorell questionnaire was 9%.

The statistical analyses were performed using SPSS® version 16.0. Comparisons between farmers and non-farmers regarding baseline factors were made using a t-test for continuous variables and a Chi^2-test for categorical data. Multiple logistic regression models were applied to analyze associations between lifestyle factors and T2D as well as components of the metabolic syndrome and T2D with regard to farmers. The analyses were carried out in a stepwise manner. The results are presented as odds ratios (OR) with 95% confidence intervals (95% CI).

RESULTS

National registers (National Cause of Death Register, Hospital Patient Register and Patient Register) have listed 403 individuals with diabetes diagnosed out of totally 3,569 individuals. That is 11% of the studied population. In the registers, farmers had a significantly lower cumulative incidence of diabetes than rural non-farmers and urban referents (Table 3).

The farmers and the rural non-farmers were surveyed twice in 1990-91 and in 2002-03. Some individuals (n=21) reported at these surveys that they had diabetes and/or were on treatment for diabetes although they were not listed in the national registers. Thus, during the period 1989-2003, 15.9% of the individuals with diabetes were not listed in national registers. If this rate of non-registered individuals were the same for the rest of the follow-up period another 12 individuals have probably contracted diabetes but were not possible to include in our material.

In the surveyed population, 212 individuals with a verified diabetes diagnosis were identified (Table 4). Of them, 41 men reported diabetes in 1990-91. These 41 men were all asked about diabetes treatment and 19 reported taking insulin. These 19 individuals were regarded as type 1 diabetes and were excluded from the subsequent analyses. The later analyses were thus based on a population of 1,944 individuals (1,070 farmers and 874 non-farmers).

A total of 91 farmers (8.4%) and 102 non-farming rural referents (11.5%) were identified as individuals with T2D. This results in an unadjusted OR=0.70 (95% CI: 0.52-0.95) for the farmers relative to the non-farming referents. Nine farmers and 13 rural referents had developed T2D before 1989 and 82 farmers and 89 referents during the 20-year period from 1989-2009. Transformed to an annual incidence rate, the observed frequency gives 383 new cases for the farmers and 509 for the non-farming referents per 100,000 individuals and year.

The studied baseline variables showed significant and systematic differences between farmers and rural non-farmers (Table 5). Farmers had greater physical capacity, scored higher for meal quality, smoked less, consumed less alcohol but reported higher scores for experienced demands at work. The three possible mediators between lifestyle and T2D analyzed (obesity, blood pressure and blood lipids) also showed significant differences between farmers and rural referents. The farmers had lower waist/hip ratio, lower blood pressure and lower concentrations of serum triglycerides.

The relationship between lifestyle factors and T2D is shown in Table 5. Physical work capacity and meal quality index showed a significant association with T2D whereas smoking, alcohol consumption and experienced demands at work did not. The three metabolic mediators (obesity, blood pressure and blood lipids) were, as expected, significantly related to T2D.

Logistic regression analyses were performed in order to determine whether the low observed risk of T2D among farmers can be explained by lifestyle factors. After adjusting for physical capacity and meal quality, the lower risk of T2D among farmers became non-significant (OR=0.88; 95% CI 0.61-1.25), indicating that status as a farmer per se had no impact on the T2D risk (Table 6). Further adjustments for smoking, alcohol consumption and experienced demands did not affect the results.

In a separate analysis, the risk of T2D among farmers was adjusted for the studied metabolic mediators. Adjustment for obesity, blood pressure and blood lipids also fully explained the low risk of T2D among farmers.

DISCUSSION

Farmers in Sweden and other industrialized countries are at low relative risk of developing cardiovascular disorders.[6-8] Our study showed that farmers are also at low risk of developing T2D. The low risk of developing T2D was explained by lifestyle factors; physical capacity and meal quality.

Farmers in Sweden and presumably also in many other countries have a relatively favourable lifestyle, which seems to be health-promoting in this context. The crude risk of T2D among farmers was approximately 30% lower than among rural men in the same districts. Thunander and co-workers reported a T2D incidence in a Swedish district based on observations over a three-year period (1998-2001).[24] Their findings indicate an annual calculated incidence rate of approximately 600 per 100,000 individuals in comparable age groups in the general population. Our findings suggest a lower incidence rate among both farmers and rural non-farming men than found by Thunander et al.

We identified diabetes using national registers and information from two surveys with an interval of more than ten years. All cases were not listed in the registers, indicating that our method of retrieving cases improved the incidence rating. Still, some cases, especially from later years after the second survey, were probably missed. The shortcomings of the registers are related to the fact that general practitioners do not report to the registers in Sweden. Only specialists affiliated with the hospitals are required to consecutively report to the registers.

The rural part of the study population is a representative sample from the Swedish countryside.[8] The surveys were performed in nine different districts around the country and the areas were chosen in line with known health gradients.[18]

The quality of data has been evaluated in a number of studies. The internal loss of data is generally low and previously proved methods and validated questionnaires

Table 1. Study population

	Register study		Survey 1990-91		Survey 2002-03		Both surveys		At least one survey	
	n	%	n	%	n	%	n	%	n	%
Whole study population	3,569		2,350		2,350		2,350		2,350	
Participation	3,569	100	1,782	75.8	1,586	68.5	1,405	59.8	1,963	83.5

Table 2. Meal quality index

Type of meal	Before 08	08 - 11	11 - 14	14 - 16	16 - 19	After 19	Meal quality index
Just something to drink such as coffee, beer, juice or milk	1	1	1	1	1	1	
A drink and snacks and/or a cake, etc.	2	2	2	2	2	2	
A drink and a sandwich	3	3	3	3	3	3	
A meal with yoghurt and/or cereals and/or porridge and/or a sausage etc.	4	4	4	4	4	4	
A full meal with meat or fish, potatoes or pasta, etc.	5	5	5	5	5	5	
Sum	**4**	**1**	**5**	**0**	**4**	**3**	**17**

Meal data from six periods of the day two or three hours each. Example in grey.

Table 3. Diabetes frequencies in the study population according to national registers 1989-2009

Groups	n	Dead during follow up. Diabetes main diagnosis		Diabetes diagnosis in registers	
		n	%	n	%
Farmers	1,220	2	0.2	113	9.3
Rural referents	1,130	5	0.4	147	13.0
Urban referents	1,219	15	1.2	143	11.7
p-value (Chi^2)			0.002		0.014

All kinds of diabetes among farmers, non-farming rural referents and referents living in medium sized cities.

Table 4. Diabetes frequencies in the rural subpopulation according to national register and interviews

Groups	n	All diabetes (1989-2009)		Diabetes 1990/91[††]		Diabetes type II (T2D)[†]	
		n	%	n	%	n	%
The rural subpopulation	1,963	212	10.8	41	2.1	193	9.8
Farmers	1,079	100	9.3	18	1.7	91	8.4
Non-farmers	884	112	12.7	23	2.6	102	11.5
p-value[*]			0.016		0.150		0.020

[†] T2D defined as diabetes diagnosed after 1990-91 and non-insulin dependent diabetes 1990-91.
[††] In this group of 41 individuals, 27 had some sort of medication and among those 27 individuals 19 were on insulin. These 19 individuals were regarded as type I diabetics.
[*] Chi^2 (farmers versus non-farmers).

have mainly been used.[19] To estimate meal quality we developed a standardized interview to perceive the differences among individuals concerning different meal compositions, generating a meal quality index. Internal validation has not shown any disqualifications as the distribution, standard deviation, skewness and kurtosis all indicate that the variable is normally distributed. At the time (1989) we did not find any other applicable method for analyse of meal quality. The meal structure, not only the diet components with respect to diabetes, needs more attention.

The metabolic syndrome includes the clustering of abdominal obesity, insulin resistance, dyslipidemia and elevated blood pressure.[16] The different components may be regarded as mediators of lifestyle impacting the risk of T2D. In this study, abdominal obesity (waist/hip ratio), dyslipidemia (triglycerides) and diastolic blood pressure were related to T2D as expected. Most previous studies on T2D and occupation use BMI as a measure of overweight and obesity. We used waist/hip ratio because there is strong support for waist/hip ratio as a better indicator of abdominal obesity than BMI.[25,26]

A negative relationship between physical activity and T2D is supported by many studies.[27,28] Physical activity has a correlation to other factors with impact on the T2D risk including adiposity, blood pressure, dyslipidemia and inflammation. It is not clear whether the positive effect of physical activity is attributed to exercise per se or the result of favourable changes in body composition.[29] The effects of physical activity may be modified by a number of diabetes genes. This modification, however, is assumed to be of moderate size.[30,31]

Physical activity can be estimated in different ways. Most studies report physical activity information based on questionnaires. We have made correlation analyses of physical work capacity as previously described as well as physical work load according to the Edholm scale and physical leisure activities.[32] These analyses indicate that physical work capacity is a better indicator in this context than physical leisure activities or physical workload estimated using standardized interviews.

Other studies support our finding indicating that not only the nutritional composition of the diet impacts the T2D risk but also meal quality expressed as regular meals.[33,34] However, this field of research seems to have been sparsely studied. More information is needed to understand how food and meal structure interact with other lifestyle factors related to T2D.

In our analyses, none of smoking, alcohol consumption or stress had any significant relation to the T2D risk. We are well aware that experienced work demands according to Karasek/Theorell are just one aspect of the broad concept of stress. Other methods may of course be used.[35]

Conclusion

We found that Swedish farmers seem to have a lower incidence of T2D than urban and rural referents. Further analyses showed that the low risk could be explained by higher physical capacity and better meal quality among the farmers when compared with rural referents in the same local areas. The status as a farmer thus did not have any direct relation to T2D.

Our results are well on line with what is known about lifestyle factors and T2D as well as the relation of the components of the metabolic syndrome and T2D. Healthy eating patterns (meal quality) as well as physical activity are health promoting factors shown to be of importance here in explaining a low incidence of T2D in an occupational group.

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AUTHOR DISCLOSURES

The authors declare no conflicts of interest.

Table 5. Studied variables at baseline and their relation to diabetes type II (T2D) during follow-up

Life style factors	Analyzed variables	n	Farmers	Non-farmers	*p*-value*	Individuals with diabetes type II (T2D)	Individuals without diabetes	*p*-value*
			$\bar{x}$ or %	$\bar{x}$ or %		$\bar{x}$ or %	$\bar{x}$ or %	
Physical activity	Physical work capacity (L/min)	1,648	2.97	2.73	<0.001	2.69	2.88	<0.001
Food	Meal quality index	1,710	15.6	14.9	<0.001	14.5	15.4	<0.001
Smoking	Yes (%)	1,761	17.5	30.6	<0.001	24.9	23.0	<0.001
Alcohol consumption	Total consumption (g/week)	1,758	20.3	31.0	<0.001	23.5	25.1	0.499
Stress	Demand on work (scale)	1,624	13.2	12.0	<0.001	12.3	12.7	0.067
Possible mediators								
Overweight/obesity	Waist/hip ratio	1,752	0.906	0.919	<0.001	0.951	0.908	<0.001
Blood pressure	Diastolic pressure (mm Hg)	1,763	77.3	80.1	<0.001	82.4	78.1	<0.001
Dyslipidemia	Triglycerides (mmol/L)	1,758	1.80	2.00	<0.001	2.77	1.80	<0.001

* t-test or Chi^2-test.

Table 6. Diabetes among farmers and lifestyle factors

Farmers risk	OR	95% CI
Crude risk	0.70	0.52-0.95
After adjusting for physical capacity (work ergometer test)	0.81	0.57-1.14
After adjusting for physical capacity and meal quality (meal quality index)	0.88	0.61-1.25
After adjusting for physical capacity, meal quality and smoking	0.86	0.60-1.22
After adjusting for physical capacity, meal quality, smoking and alcohol consumption	0.81	0.57-1.17
After adjusting for physical capacity, meal quality, smoking, alcohol consumption and stress (psychological demands)	0.87	0.59-1.29

Crude risk rate and risk after adjusting for lifestyle factors.

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农民及农村和城市参照人群中 2 型糖尿病 20 多年的累计发病率和危险因素研究：前瞻性队列研究

背景：很少有研究探讨 2 型糖尿病在不同职业人群中的患病风险。在瑞典，农民的冠状动脉心脏病患病风险较低，但是关于糖尿病的患病风险知之甚少。目的：分析农民和参照人群中 2 型糖尿病的累积发病率和相对危险度，以及生活方式因素和代谢综合征的组成部分。方法：在纵向观察队列研究中，我们跟踪调查 1,220 位农民、参照人群 1,130 位农村非农业居民和 1,219 位城市居民 20 余年。数据来自国家的登记注册和相隔 12 年的两次调查数据，其中 1990 到 1991 年期间进行的第一次调查结果作为基线数据。结果：农民糖尿病的患病风险显著低与农村非农业居民和城市居民(p<0.05)。在跟踪调查的 20 多年中，总共有 91 名农民(8.4%)和 102 名农村非农业居民(11.5%)被诊断出患有 2 型糖尿病(OR=0.70，95% CI 0.52-0.95)。基于生活方式因素和代谢综合征的组成部分分别统计分析数据显示，农民的 2 型糖尿病低患病风险可以用其体力活动和膳食质量来解释。农民的体力活动(p<0.001)和膳食质量指数(p<0.001)都显著高于农村非农业人口。结论：在瑞典，农民 2 型糖尿病有显著低的患病率。其较低的相对危险度可解释为其更多的体力活动和更好的膳食质量。这表明农民的生活方式和他们的工作环境是有利于健康的。

关键词：2 型糖尿病、农民、生活方式、体力活动、膳食质量