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Prevalence of diabetes mellitus and IFG in the prospective cohort 'PONS' study – baseline assessment

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Abstract

Objective: The aim of this cross-sectional study was to assess the prevalence of diabetes mellitus and impaired fasting glucose (IFG) in the Polish-Norwegian Study (PONS) population in Poland.

Methods: The presented results are part of the PONS project, and cover information from 3,854 people aged 45-64 (2,567 females and 1,287 males) who are inhabitants of Świętokrzyski Province.

Results: In the study group there were 62.8% participants with normoglycaemia, 28.9% participants with IFG and 8.4% participants with diabetes. In those with diabetes, there were 95 participants (2.5%) whose diabetes was unknown prior to this study. Among 5.9% patients with known diabetes 52.9% of the participants had a fasting blood glucose level of ≥126 mg%. There were 46.8% males and 70.8% females with normoglycaemia, 41.0% males and 22.8% females with IFG, and 12.2% males and 6.4% females with diabetes. The prevalence of diabetes was higher in participants in the older age group (55-64) compared to younger participants (45-54). The prevalence of diabetes decreased with increasing education and was higher among overweight or obese participants compared to normal weight participants.

Conclusion: The prevalence of diabetes mellitus in study population was generally high, but especially high in males, and the awareness of diabetes in the population was generally low. Among participants with known diabetes more than half was not well controlled.

Keywords

prospective study, prevalence of diabetes mellitus, IFG, Poland, PONS

INTRODUCTION

Diabetes mellitus is a chronic disease associated with the prevalence of many metabolic disorders whose common feature is hyperglycaemia resulting from an insufficient insulin secretion or its malfunction. 90% of these disorders are associated with type 2 diabetes, insulin resistance, and reduced insulin secretion by pancreatic islet cells. It has a close relationship with the human lifestyle, especially irregular eating habits and low physical activity. People with abnormal body weight develop diabetes 2-4 times more often. Until recently, type 2 diabetes was a disease of older people. For the past several years it has also been diagnosed among children, mainly due to the expansion of obesity [1-3].

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The World Health Organization (WHO) reports that 346 million people worldwide have diabetes, and the Index of morbidity due to diabetes in European countries is at a level of 3-6% and in Poland at its upper limit – more than 5%, which represents 2 million people. Additionally, it is estimated that 10% of the Polish population have hyperglycaemia – a pre-diabetic illness which accounts for an additional 4 million people [4]. The International Diabetes Federation (IDF) forecasts the worldwide diabetes prevalence to rise from 6.4% in 2010 to 7.7% in 2030, and pre-diabetic state from 7.8% in 2010 to 8.4% in 2030 [5]. The danger associated with such a huge number of people with diabetes or with a pre-diabetic state as impaired fasting glucose is related to diabetic complications: microvascular (retinopathy, nephropathy and neuropathy) and macrovascular (coronary heart disease and vascular diseases including stroke). In 2004, it was estimated that 3.4 million people died because of complications associated with a high blood glucose level, and from 2005-2030 this number is expected to double. 50% of people with diabetes die from cardiovascular disease (CVD)

– heart disease or stroke. In Poland, diabetes is a leading cause of kidney failure (nephropathy), blindness (retinopathy) and lower limb amputation due to diabetic foot [6-8]. Prevention and well treatment of diabetes will reduced CVD mortality [9] Therefore, it is a disease that should be recognized early and properly treated with a special measures for prevention.

MATERIALS AND METHODS

This study presents preliminary analysis data from the first wave of participants of the Polish-Norwegian Study (PONS) in the Kielce region of Poland. The PONS study is a large open-ended prospective study with very broad research aims. The ultimate aim of the study is to advance our understanding of important causes of morbidity and mortality in Poland, and to establish a solid knowledge base for the prevention of these major causes of premature morbidity and mortality.

Sample and data collection. Study covered a group of 3,854 people aged 45-64 years (2,565 females and 1,289 males), among them, 1,176 rural and 2,678 urban inhabitants. All participants were tested according to the PONS project protocol.

Every participant had to answer a health survey and had fasting blood sample taken. Based on this information, the overall study group was further divided into 2 reference groups (Fig.1):

1. participants with impaired fasting glucose (IFG - fasting glucose's level between 100 mg% and 125 mg%,) – further referred to as *IFG Participants;*
2. *participants with diabetes* (diabetes confirmed during the health survey or/and tested fasting glucose levels ≥ 126 mg %). The diabetic participants were further divided to 2 subgroups:
   a. participants confirmed in the health survey as having diabetes – participants with *known diabetes;*
   b. participants confirmed in the health survey as not having diabetes – participants with *unknown diabetes*.

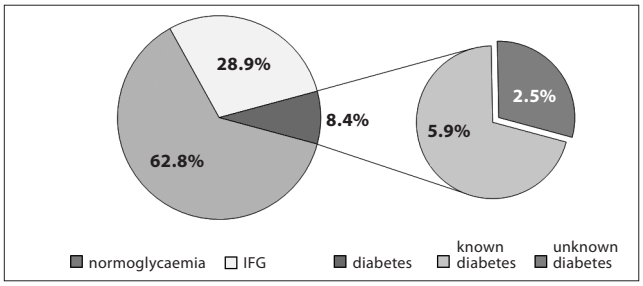

Figure 1. Study group divided to reference groups

Measurements. All participants had basic anthropometric measurements taken, such as height, weight, waist and hips size. Body Mass Index (BMI kg/m^2) was classified according to WHO guidelines into 4 categories as being: underweight (BMI<18.5 kg/m^2), normal weight (BMI 18.5-24.9 kg/m^2), overweight (BMI 25.0-29.9 kg/m^2), and obese (BMI≥ 30.0 kg/m^2).

Abdominal obesity was defined by 2 waist circumference categories: according to IDF criteria (males ≥94 cm and females ≥80 cm) and NCEP ATP III criteria (males ≥102 cm and females ≥88 cm). Abdominal obesity was also classified by 2 WHR categories (males ≥1.0 and females ≥0.8) and WHR (males ≥0.94 and females ≥0.8).

Statistical analysis. Mean (±SD) were calculated to summarize continuous variables. For all analysis, the criterion for statistical significance was set at alpha ≤0.05. Statistical analysis was performed using computer programme STATISTICA v 9.1 PL StatSoft Inc., USA.

Ethics. The study was approved by the Ethics Committee of the Cancer Centre and the Institute of Oncology in Warsaw, Poland.

RESULTS

The mean fasting glucose level in the study group is presented in Table 1. The mean fasting blood glucose level measured in the overall study group was 99.6 mg%. Blood glucose level was significantly higher for males compared to females (104.8 vs 97.0 mg%, respectively) and for participants aged 55-64 than aged 45-54 (101.9 vs 96.4 mg%, respectively). There were no significant differences in blood glucose level between rural and urban inhabitants (99.5 vs 99.7 mg%). It was found that blood glucose level significantly decreased with increasing education level: primary education – 106.4 mg%, trade education – 104.0 mg%, secondary education – 98.8 mg% and university education – 97.2 mg%.

Among participants with known diabetes, the fasting blood glucose level was not significantly different between males

Table 1. Comparison of mean (±SD) fasting blood glucose level in the study group depending of the prevalence of diabetes

Study group	Overall		Participants with fasting blood glucose level ≥126mg% or with known diabetes		Participants with known diabetes		Participants with unknown diabetes	
	No.	Mean (SD)	No.	Mean (SD)	No.	Mean (SD)	No.	Mean (SD)
Males	1,289	104.8 (24.7)	157	143.2 (48.9)	98	143.6 (59.2)	59	142.5 (23.7)
Females	2,570	97.0 (21.5)	165	144.3 (58.6)	129	145.0 (64.9)	36	141.4 (25.7)
45-54 y.o.	1,586	96.4 (17.3)	73	135.7 (47.6)	40	131.7 (60.0)	33	140.4 (25.9)
55-64 y.o.	2,273	101.9 (25.9)	249	146.1 (55.6)	187	147.1 (62.7)	62	143.0 (23.7)
Rural	1,180	99.5 (26.1)	89	152.4 (69.3)	68	156.5 (78.3)	21	139.4 (18.1)
Urban	2,679	99.7 (21.4)	233	140.4 (46.6)	159	139.3 (53.7)	74	142.9 (25.9)
Primary education	230	106.4 (36.7)	41	156.1 (64.1)	36	160.0 (67.6)	5	128.1 (0.8)
Vocational education	687	104.0 (34.3)	89	155.3 (73.4)	60	161.5 (88.2)	29	142.6 (16.5)
Secondary education	1,707	98.8 (17.9)	118	137.2 (40.9)	85	134.5 (44.6)	33	144.3 (28.3)
University education	1,235	97.2 (16.5)	74	133.4 (31.3)	46	128.5 (32.4)	28	141.5 (28.1)
Total	3,859	99.6 (22.9)	322	143.7 (54.0)	227	144.4 (62.4)	95	142.1 (24.4)

and females (143.6 vs 145.0 mg%) nor between rural and urban inhabitants (156.5 vs 139.3 mg%). Though, significant differences were observed between age groups 45-54 and 55-64 (131.7 and 147.1 mg%), and with respect to education, participants with primary and vocational education (160.0 mg%, 161.5 mg%) had significantly higher blood glucose levels than participants with secondary and university education (134.5 mg%, 128.5 mg%).

Participants with unknown diabetes had mean blood glucose at a level of 142.1 mg% (142.5 mg% males and 141.4 mg% females). There were no significant differences between rural and urban inhabitants, nor between age groups. Participants with primary education had lower blood glucose levels than patients with vocational, secondary and university education (128.1, 142.6, 144.3 and 141.5 mg%, respectively) (Tab. 1).

The study group included 62.8% patients with normoglycaemia, 28.9% patients with IFG, and 8.4% participants with a fasting blood glucose level of ≥ 126 mg%, or with known diabetes. The group with a fasting blood glucose level of ≥ 126 mg% accounted for 2.6% without known diabetes. Among participants who declared diabetes in the interview, 52.9% patients had fasting blood glucose level ≥126mg%.

46.8% of males had normoglycaemia, 41.0% of males had IFG, and 12.2% of males with a fasting blood glucose level of ≥ 126 mg%, or had known diabetes. Among the males with known diabetes 52.0% had a fasting blood glucose level of ≥ 126mg%. Statistically less frequent IFG and diabetes were observed in females. 70.8% of females had normoglycaemia, 22.8% of females had IFG, and 6.4% of females had a fasting blood glucose level ≥126 mg%, or had known diabetes. Among the females with known diabetes 53.5% had a fasting blood glucose level above 126mg% (Tab. 2).

There were no significant differences in the prevalence of diabetes between rural and urban inhabitants. Among rural inhabitants, 64.2% of patients had normoglycaemia, 28.2% of patients had IFG, and 7.6% of patients had a fasting blood glucose level above 126 mg%, or had known diabetes. Among urban inhabitants, the percentages were 62.1, 29.2 and 8.7%, respectively. IFG and diabetes were observed statistically more frequently in males from the rural area (42.7% and 10.4%, respectively) than in females from the rural area (20.9% and 6.2%). A similar correlation was found among urban inhabitants. The prevalence of IFG and diabetes was statistically more frequent in males (40.3% and 13.0%, respectively) than females (23.6% and 6.6%, respectively) (Tab. 3).

Table 2. Prevalence of IFG and diabetes mellitus by gender

Level of Glucose	Males		Females		Total		P
	No.	%	No.	%	No.	%	
Total							
Normoglycaemia (<100mg%)	603	46.8	1816	70.8	2419	62.8	<0.001
IFG (100-125mg%)	529	41.0	584	22.8	1113	28.9	
Diabetes (≥126mg%)	157	12.2	165	6.4	322	8.4	
Participants without known diabetes							
Normoglycaemia (<100mg%)	603	50.7	1816	74.6	2419	66.7	<0.001
IFG (100-125mg%)	528	44.4	584	24.0	1112	30.7	
Diabetes (≥126mg%)	59	5.0	36	1.5	95	2.6	
Participants with known diabetes							
Normoglycaemia (<100mg%)	12	12.2	21	16.3	33	14.5	0.5602
IFG (100-125mg%)	35	35.7	39	30.2	74	32.6	
Diabetes (≥126mg%)	51	52.0	69	53.5	120	52.9	

Table 3. Prevalence of IFG and diabetes mellitus by place of residence

Level of glucose	Males		Females		Total		p
	No.	%	No.	%	No.	%	
Rural							
Normoglycaemia (<100mg%)	186	47.0	569	73.0	755	64.2	<0.001
IFG (100-125mg%)	169	42.7	163	20.9	332	28.2	
Diabetes (≥126mg%)	41	10.4	48	6.2	89	7.6	
Urban							
Normoglycaemia (<100mg%)	417	46.7	1,247	69.9	1,664	62.1	<0.001
IFG (100-125mg%)	360	40.3	421	23.6	781	29.2	
Diabetes (≥126mg%)	116	13.0	117	6.6	233	8.7	

The prevalence of IFG and diabetes by age is shown in Table 4. Older participants (55-64) had diabetes statistically more frequently than the younger group (45-54). There were 57.9% vs 69.7%, respectively, of patients with normoglycaemia, 31.2% vs 25.6% of patients with IFG, and 10.9% vs 4.7 of patients with a fasting blood glucose level of ≥ 126 mg%, or had known diabetes. 2.1% of patients had unknown diabetes among those with a fasting blood glucose level above 126 mg% in the age group 45-54, and 3.0% among patients in the age group 55-64. It was observed that there were respectively 42.5% and 55.1% of patients who had known about diabetes, but their fasting blood glucose level was ≥ 126 mg% (Tab. 4).

The prevalence of diabetes decreased with increasing education level and amounted respectively: 18.1% in patients with primary education, 13.0% with vocational education, 6.9% with secondary education, and 6.1% with higher education. The IFG was less corelating with the level of education. IFG had 27.3% of participants with primary education, 30.2% of participants with vocational and secondary education, and 26.6% with university education. It was found that the

Table 4. Prevalence of IFG and diabetes mellitus by age

Level of glucose	45-54 y.o.		55-64 y.o.		P
	No.	%	No.	%	
Total					
Normoglycaemia (<100mg%)	1,106	69.7	1,313	57.9	<0.001
IFG (100-125mg%)	406	25.6	707	31.2	
Diabetes (≥126mg%)	74	4.7	248	10.9	
Participants without known diabetes					
Normoglycaemia (<100mg%)	1,106	71.6	1,313	63.1	<0.001
IFG (100-125mg%)	406	26.3	706	33.9	
Diabetes (≥126mg%)	33	2.1	62	3.0	
Participants with known diabetes					
Normoglycaemia (<100mg%)	12	30.0	21	11.2	0.0093
IFG (100-125mg%)	11	27.5	63	33.7	
Diabetes (≥126mg%)	17	42.5	103	55.1	

prevalence of normoglycaemia increased with increasing education level of the study group and amounted to 54.6%, 56.9%, 62.9% and 67.3%, respectively (Tab. 5).

Table 5. Prevalence of IFG and diabetes mellitus by level of education

Level of glucose	Level of education								p
	Primary		Vocational		Secondary		University		
	No.	%	No.	%	No.	%	No.	%	
Normoglycaemia (<100mg%)	124	54.6	390	56.9	1074	62.9	831	67.3	<0.001
IFG (100-125mg%)	62	27.3	207	30.2	515	30.2	328	26.6	
Diabetes (≥126mg%)	41	18.1	89	13.0	118	6.9	75	6.1	

The correlation between prevalence of diabetes and obesity was analyzed. Mean BMI in the study group was 28.3 kg/m^2 and was significantly higher in those participants with IFG (29.4 kg/m^2) and diabetes (31.1 kg/m^2) than in the participants with normoglycaemic (27.4 kg/m^2) (Tab. 6). The percentage of participants with abdominal obesity, defined by both the waist circumference and WHR, was significantly higher among those with IFG and diabetes than among the normoglycaemic participants. Among patients with IFG, 82.9% had abdominal obesity (defined by IDF) and 86.0% had diabetes. Taking into account NCEP ATP III criteria, 50.5% of participant had abdominal obesity among participants with IFG, and 64.9% among those with diabetes. Respectively, 61.3% and 73.0% of participants had abdominal obesity defined by WHR (1.0 for males and 0.8 for females). Taking into account WHR ≥0.94 for males and ≥0.8 for females, 79.2% of participants had abdominal obesity among those with IFG, and 87.9% among those with diabetes (Tab. 7).

Table 6. Correlation between diabetes mellitus and BMI

Level of glucose	No.	BMI (kg/m^2)		P
		Mean	SD	
Normoglycaemia (<100mg%)	2,416	27.4	4.4	
IFG (100-125mg%)	1,108	29.4	4.3	<0.001
Diabetes (≥126mg%)	322	31.1	5.3	
Total	3,846	28.3	4.6	

Table 7. Correlation between diabetes mellitus and abdominal obesity

		Normoglycaemia (<100mg%)	IFG (100-125mg%)	Diabetes (≥126mg%)	p
Waist circumference[1]	Normal	64.5%	49.5%	35.1%	<0.001
	Obesity	35.5%	50.5%	64.9%	
Waist circumference[2]	Normal	35.6%	17.1%	14.0%	<0.001
	Obesity	64.4%	82.9%	86.0%	
WHR[3]	Normal	30.6%	20.8%	12.1%	<0.001
	Obesity	69.4%	79.2%	87.9%	
WHR[4]	Normal	38.7%	38.7%	27.0%	0.0016
	Obesity	61.3%	61.3%	73.0%	

[1] Abdominal obesity: waist >102 (males); >88 (females)
[2] Abdominal obesity: waist >94 (males); >80 (females)
[3] Abdominal obesity: WHR ≥0.94 (males); ≥0.8 (females)
[4] Abdominal obesity: WHR ≥1.0 (males); ≥0.8 (females)

The risk of diabetes was significantly higher in participants with overweight or obesity than in those with normal weight (odds ratio [OR] = 2.40; 95% Cl = 2.00-2.88). The risk of diabetes was also significantly higher in participants with abdominal obesity (according to IDF) than in patients without abdominal obesity (odds ratio [OR] = 2.61; 95% Cl = 1.89-3.61).

DISCUSSION

The overall study population had a mean fasting glucose level of 99.6 mg%, greater for males (104.8 mg%) than for females (97.0 mg%). When the glucose levels of the population in the PONS study were matched with other Polish data [10], the results were comparable in the case of males; however, in case of females, slightly lower. The prevalence of diabetes in the PONS study population was 8.4% compared to 5.3% in the PWBEC study conducted between 1998-2000, and 5.6% from the NATPOL study conducted between 1994-2002, all of them less than the presented PONS study data [11,12]. Considering the fact that diabetes can take many years before being diagnosed – some references stretch this period from 4-7 years, and that out of all the cases half are undisclosed – the actual prevalence of diabetes is difficult to stipulate accurately [13-15]. The prevalence of unknown diabetes in the PONS study population accounts for 1/3 of all cases. This may seem that in terms of healthcare prevention, compared to the rest of the country, things are better in Świętokrzyski Province, although other alerts arise from prediabetic status indicators. The PONS study group showed that 29% of participants developed the IFG state, which is only 10% for the total Polish population [14].

The fasting glucose level among participants with known diabetes shows significant differences when gender, age, place of residence and education are taken into account; known diabetes participants also present greater differences within the relevant groups. None of this is present among unknown diabetes participants who present lower mean values, with lower variance and hardly any differences between the relevant groups.

The PONS study data is striking becouse it shows large and significant differences in blood glucose levels between males and females. Over 70% of females had normal glucose level, while over 50% of males had a glucose level over 100 mg%, and such differences in glucose level distribution between genders was noted among known and unknown diabetics. This certainly needs further investigation, but so far, we can only proffer the statement that gender is a risk factor for evolving the IFG state or diabetes type 2. This is directly linked to other risk factors, such as obesity and abdominal obesity – widely-recognized as a reliable indicator of risk of developing diabetes type 2 [16]. Abdominal obesity was commonly observed in the study group. The higher risk of males developing the IFG state or diabetes is associated with the general tendency of being obese. The rise of odds ratio of developing the IFG state or diabetes correlated to the prevalence of abdominal obesity what confirms this as a relevant risk factor.

Gender differences in the prevalence of diabetes were also observed in a Greek study [17], but only in older population. This may indicate that the difference with respect to gender observed in the PONS study is rather an age-gender pattern,

and the situation could be different for the younger-adult population.

Based on the PONS data, also investigated were the differences in blood glucose level, hence IFG/diabetes, with respect to education - probably the key component as it can lead to improper eating habits that further lead to obesity and/or IFG state and/or diabetes. A bad socio-economic status enforces this process, as a person may have less resources and time to eat healthy.

The large proportion of undisclosed diabetes points to the necessity for a large- scale screening programme into diabetes or risk of diabetes. Such preventive medical actions could be conducted in the practices of family physicians, occupational medicine, at places of work, and elsewhere. This, together with tackling the risk factors, could be a cheap and effective action to save patients years of life lost, and save social and healthcare funds from expenditure on diabetes and its complications.

Diabetes mellitus was compared to a plague, with high fat and high calorie diets as pathological agents of the environment [18]. The significant rise in the prevalence of diabetes (1960s-2% - 2000-8%) since the 1960s and throughout the consecutive decades, was assigned to environmental factors. This theory claims that if the environmental factors could be eradicated, the prevalence of diabetes in the population would be reduced to its previous level. Some environmental factors could be easier and some more difficult to deal with, but studies show that much is dependent upon living habits. These can be changed through education among the youngest, and a process of behavioural change among adults, imposing specific safety regulations, food labelling regulations, etc. The EU and Polish regulations concerning food safety partially relate to these problems [19]. The PONS study is another opportunity of disclosing the ranges of specific risk factors needed to be addressed.

Limitations. The presented results are a preliminary cross-sectional analysis of the participants of an on-going cohort study in Poland. More females than males, and more participants aged 55-64 than 45-54 have been recruited to the study to-date – mainly those with secondary and university education. A large proportion of the males and participants with primary education who participated had diabetes. The estimated results for diabetes might not be fully representative for the Świętokrzyskie Province.

CONCLUSION

The prevalence of diabetes in this population was generally high, especially high in males, and the awareness of diabetes in the population was generally low. Among participants with known diabetes, more than a half of the patients were not well controlled.

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