Impaired Fasting Glucose, Diabetes Mellitus and Coronary Risk Factors

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Abstract

The authors conducted a prevalence survey of impaired fasting glucose and diabetes mellitus in 3,615 Shinawatra employees, and we also determined various risk factors of coronary artery disease such as blood pressure level, body mass index and serum lipids. The prevalence of impaired fasting glucose and diabetes mellitus were 1.7 per cent and 0.8 per cent respectively. The prevalences were more common in males and increased with increasing age. Coronary risk factors were higher in impaired fasting glucose (IFG) and diabetes mellitus (DM) when compared with normal glucose levels. There were also significant differences between impaired fasting glucose and diabetes mellitus, except for pulse pressure, serum cholesterol level, LDL-cholesterol level and HDL-cholesterol level.

Key word : Impaired Fasting Glucose, Diabetes Mellitus, Coronary Risk Factors

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Background and Rationale

In 1997, the American Diabetes Association (ADA) published criteria for the diagnosis and classification of diabetes mellitus and related glucose disturbances[1]. In the absence of weight loss, polyuria, polydipsia, and a blood glucose concentration 2 hours after load of at least 11.1 mmol/L, these new criteria rely primarily on fasting glucose values. The advantage of the ADA criteria is that they do not require oral glucose tolerance testing with 2 hour glucose measurements, as set forth by the WHO criteria[2]. By simplifying the diagnosis

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of diabetes mellitus, ADA hoped that the diagnosis of glucose metabolic disturbances would be simpler and less of a burden to patients, more readily accepted by the medical community, and would lead to earlier detection and treatment of individuals with diabetes mellitus.

The fasting ADA criteria establish a fasting glucose concentration of at least 7.0 mmol/L for the diagnosis of diabetes mellitus, which is lower than the corresponding WHO criteria of at least 7.8 mmol/L. This lower cutoff point was chosen because the microvascular eye and kidney diseases that are unique to diabetes mellitus begin to become more prevalent at this concentration. The fasting ADA criteria also define a new class of glucose disturbance called impaired fasting glucose (fasting glucose 6.1-6.9 mmol/L), which differs from the WHO category of impaired glucose tolerance (fasting glucose <7.8 mmol/L and 2 hour glucose >7.7 mmol/L and less than 11.1 mmol/L). Several studies had also shown that impaired glucose tolerance was associated with increased prevalence of coronary risk factors and cardiovascular mortality[3-26], but little is known concerning impaired fasting glucose. Our study examined the prevalence of coronary risk factors in impaired fasting glucose and diabetes mellitus in a population survey of 3,615 Shinawatra employees.

MATERIAL AND METHOD

A cluster sampling survey was performed amongst Shinawatra employees, who were relatively young, highly educated and have high socioeconomic status. A self-administered questionnaires concerning demographics, education, family income, presence of heart disease and risk factors, physical activity, stress, alcohol consumption and angina history using the Rose and Blackburn questionnaire was conducted.

Standing height was measured with the subject in bare feet, back square against the wall and eyes looking straight ahead. Weight was measured in undergarments, using balanced scales to the nearest 200 grams. The scale was standardized to 0 before each use. Waist and hip circumference was performed to the nearest 0.1 cm using a nonstretchable standard tape measure attached to a spring balance exerting a force of 750 grams (Ohaus tape). The waist circumference was taken over the unclothed abdomen at the smallest diameter, between the costal margin and the iliac crest. The tape measure was kept horizontal and just tight enough to allow the little finger to be inserted between the tape and the subject's skin. The hip circumference was taken at the level of greater trochanters (usually the widest diameter around the buttocks).

The blood pressure was done using standard mercury sphygmomanometer, twice on the right arm and the exact values recorded to the nearest 2 mmHg. A third measurement would be performed if there was 10 mmHg or more difference between the first two readings, and the average of the two closest values were used for the analysis. The correlation coefficients between the two measurements of systolic and diastolic blood pressure were 0.94 and 0.89 respectively.

Blood samples were taken after 10-12 hours fasting and were processed within 4 hours and serum stored in –70' C for further analysis. The DNA material was extracted from the WBC and stored for further analysis. The laboratory performance included complete blood count, fasting blood sugar, serum lipids (cholesterol, triglycerides and HDL-cholesterol), serum creatinine and uric acid using Hitachi 717 and 917 automation systems. The coefficients of variation between run and within run were performed every day and were less than 5 per cent. The external quality control was performed every 4 week by joining the QAP (quality assurance program) from Roche Diagnostics. The coefficients of variation for fasting blood glucose, serum cholesterol, triglycerides and HDL-cholesterol were 1.36 per cent, 2.29 per cent, 3.09 per cent and 3.45 per cent respectively. Twelve lead electrocardiography were performed on those subjects aged more than 30 years old, using the HP- Playwriter XII with the autoanalyzer and was confirmed by one of the investigators.

The data was recorded twice in the Dbase Foxpro II by two separate research assistants. If there was any discrepancy between the two values, the data would be checked and corrected. A telephone call would be made directly to the subject to obtain any missing data from the questionnaires. The completeness of our data ranged from 99.0-99.9 per cent. The statistical analysis was performed by a biostatistician using the SPSS for Window. Chi-square and analysis of variance were applied where appropriate. Multivariate analysis of covariance was used to adjust the age,sex and body mass index difference which was found amongst impaired fasting glucose, diabetes mellitus and normal.

RESULTS

A total of 3,615 subjects were studied, 1,250 (34.3%) were male and 2,365 (65.7%) were female. The mean age was 30.0 ± 5.6 years (range 18-58). Most of the population had a family income of more than 10,000 baht/month and graduated from a university or higher. A history of smoking was more common in males. The prevalence of current frequent smoking and social smoking in males was 18.5 per cent and 13.1 per cent respectively while the prevalence in females was 1.6 per cent and 6.5 per cent. The mean body mass index was 21.5 ± 3.4 kg/m^2 (range 13.7-45.1). The mean systolic and diastolic blood pressures were 113.4 ± 12.5 (range 78-188) and 75.6 ± 9.4 (range 35-139) mmHg respectively. The mean cholesterol was 200.5 ± 36.6 mg/dL (range 98-377) while the means of triglycerides and HDL-cholesterol were 91.5 ± 60.0 (range 21- 817) and 58.1 ± 14.7 mg/dL (range 13-127) respectively.

The prevalence of impaired fasting glucose (IFG) and diabetes mellitus (by blood sugar level only) were 1.7 per cent and 0.8 per cent respectively. The prevalence of impaired fasting glucose and diabetes mellitus was more common in males (3.4% *vs* 0.8% and 2.2% *vs* 0.1% respectively). The prevalence increased with increasing age as shown in Table 1.

The prevalence of hypertension, diabetes mellitus, hyperlipidemia, obesity, physical inactivity and smoking (blood pressure or blood levels and history) were 7.4 per cent, 1.4 per cent, 21.1 per cent, 13.9 per cent, 76.3 per cent and 16.3 per cent respectively. The awareness of hypertension, diabetes mellitus and hyperlipidemia was 42.2 per cent, 78 per cent and 32.9 per cent respectively.

Table 2 showed that the unadjusted coronary risk factors including systolic blood pressure, diastolic blood pressure, pulse pressure, body mass index, waist and hip circumference, waist/hip ratio, serum cholesterol, triglycerides and LDL-cholesterol were higher in IFG than in normal and were higher in DM than in IFG. While the HDL-cholesterol level was lower in IFG than in normal. There

Table 1. Age and sex stratified prevalence of impaired fasting glucose (IFG) and diabetes mellitus (DM).

		Age group (years)				
		<30 (%)	30-39 (%)	40-49 (%)	50-59 (%)	Total (%)
Male	IFG	2.3	2.3	13.2	4.5	3.4
	DM	0.5	2.7	6.6	9.1	2.2
Female	IFG	0.6	0.9	3.7	-	0.8
	DM	0.1	0.1	-	-	0.1

Table 2. Unadjusted means standard error of coronary risk factors in impaired fasting glucose, diabetes mellitus and normal population.

	Normal (n = 3,486)		Impaired fasting glucose (n = 61)		Diabetes mellitus (n = 30)	
	mean	SE	mean	SE	mean	SE
Systolic blood pressure (mmHg)	113.1	0.21	122.6	2.04	128.7	2.69
Diastolic blood pressure(mmHg)	75.37	0.16	81.3	1.47	88.6	2.20
Pulse Pressure (mmHg)	37.8	0.14	41.1	1.19	40.2	1.48
Body mass index (kg/m^2)	21.4	0.06	23.6	0.51	26.0	0.90
Waist circumference (cm)	69.1	0.17	78.4	1.51	86.8	2.52
Hip circumference (cm)	90.1	0.12	94.2	1.0	97.8	1.7
Waist / Hip ratio	0.77	0.001	0.83	0.009	0.88	0.02
Cholesterol (mg/dL)	200	0.61	220.5	5.29	222.8	9.99
Triglyceride (mg/dL)	89.3	0.95	156.2	15.64	208.3	22.45
HDL-cholesterol (mg/dL)	58.4	0.25	50.5	1.66	46.4	2.71
LDL-cholesterol (mg/dL)	123.7	0.55	138.8	4.56	134.8	8.22

SE = standard error

Remark: Normal - fasting plasma glucose < 110 mg/dl, Impaired Fasting Glucose - fasting plasma glucose 111-125 mg/dl, Diabetes Mellitus - fasting plasma glucose > 125 mg/dl.

were statistical differences between normal, impaired fasting glucose and diabetes mellitus in all parameters, except there was no significant difference between impaired fasting glucose and diabetes mellitus in pulse pressure, serum cholesterol, LDL- cholesterol and HDL-cholesterol.

Age and sex adjusted values of the risk factors were shown in Table 3. The age, sex and body mass index adjusted values of these risk factors were shown in Table 4. Coronary risk factors even after age, sex and body mass index adjusted were also higher in impaired fasting glucose than in normal.

DISCUSSIONS

The purpose of the diagnostic criteria that are based on blood glucose concentration is to identify individuals who have no symptoms of diabetes but who have hyperglycemia[27-32] and are, therefore, at increased risk of subsequent complications and mortality. Their study showed that those people who had impaired fasting glucose had a higher level of risk factors, i.e. systolic blood pressure, diastolic blood pressure, pulse pressure, body mass index, abdominal obesity and serum lipids level although they did not have any symptoms. If the purpose of screening for abnormal glucose disorder is to identify the maximum number of people at risk of cardiovascular disease, and there is an effective treatment to prevent cardiovascular disease events or death when glucose is slightly raised, then it would seem that the fasting ADA criteria of impaired fasting glucose are superior to the fasting ADA criteria for diabetes mellitus.

Table 3. Adjusted means and standard error by sex and age of coronary risk factors in normal, impaired fasting glucose and diabetes mellitus using analysis of covariance.

	Normal (n = 3,486)		Impaired fasting glucose (n = 61)		Diabetes mellitus (n = 30)	
	mean	SE	mean	SE	mean	SE
Systolic blood pressure (mmHg)	114.5	0.2	117.5	1.6	124.6	3.4
Diastolic blood pressure(mmHg)	76.4	0.2	78.2	1.2	87.0	2.6
Pulse Pressure (mmHg)	38.1	0.1	39.4	1.2	37.6	2.5
Body mass index (kg/m^2)	21.8	0.06	22.7	0.4	22.2	0.9
Waist circumference (cm)	71.2	0.1	74.2	1.1	73.9	2.3
Hip circumference (cm)	90.9	0.1	92.6	0.9	91.8	2.0
Waist / Hip ratio	0.78	0.001	0.80	0.007	0.80	0.016
Cholesterol (mg/dL)	201.2	0.6	208.4	4.9)	193.99	10.8
Triglyceride (mg/dL)	95.2	1.0	130.5	7.6	133.9	16.6
HDL-cholesterol (mg/dL)	56.7	0.2	52.7	1.9	55.8	4.2
LDL-cholesterol (mg/dL)	125.3	0.6	129.6	4.4	111.4	9.7

SE = standard error

Remark: Normal - fasting plasma glucose < 110 mg/dl, Impaired Fasting Glucose - fasting plasma glucose 111-125 mg/dl, Diabetes Mellitus - fasting plasma glucose > 125 mg/dl.

Table 4. Adjusted means and standard error by sex, age and body mass index of coronary risk factors in normal, impaired fasting glucose and diabetes mellitus.

	Normal (n = 3,486)		Impaired fasting glucose (n = 61)		Diabetes mellitus (n = 30)	
	mean	SE	mean	SE	mean	SE
Systolic blood pressure (mmHg)	114.3	0.2	116.5	1.5	124.0	3.3
Diastolic blood pressure(mmHg)	76.3	0.2	77.5	1.2	86.6	2.5
Pulse Pressure (mmHg)	38.0	0.2	39.0	1.2	37.5	2.5
Waist circumference (cm)	70.6	0.08	71.8	0.6	72.6	1.4
Hip circumference (cm)	90.4	0.07	90.6	0.6	90.8	1.2
Waist / Hip ratio	0.78	0.001	0.79	0.006	0.79	0.01
Cholesterol (mg/dL)	200.7	0.6	206.3	4.9	192.9	10.7
Triglyceride (mg/dL)	93.8	0.9	124.6	7.3	130.6	15.9
HDL-cholesterol (mg/dL)	57.1	0.2	54.1	1.8	56.6	4.0
LDL-cholesterol (mg/dL)	124.8	0.6	127.3	4.4	110.2	9.5

SE = standard error

Remark: Normal - fasting plasma glucose < 110 mg/dl, Impaired Fasting Glucose - fasting plasma glucose 111-125 mg/dl, Diabetes Mellitus - fasting plasma glucose > 125 mg/dl.

The UK Prospective Diabetes Study of newly diagnosed individuals with diabetes[33] suggests that keeping glucose concentrations low at an early stage of hyperglycaemia is important in the prevention of cardiovascular disease. Likewise, early recognition of abnormal glucose concentrations may alert the physician to more aggressively managed comorbidities such as hyperlipidemia, obesity, and hypertension. Treatment strategies for these disorders vary and depend on whether glucose abnormalities are present[34]. From our study, we cannot conclude impaired fasting glucose will progress to diabetes mellitus or lead to cardiovascular disease, although the Decode study and the study by Barzilay JI et al showed there was an increase in cardiovascular disease and death in impaired fasting glucose[35,36]. From these two studies, the impaired fasting glucose (IFG) by the new ADA criteria is less sensitive than the impaired glucose tolerance (IGT). At baseline, cardiovascular events attributable to abnormal glucose states were clearly fewer with the ADA criteria than with the WHO criteria (53 *vs* 159 cases per 10,000), largely because many more people were classified as having an abnormal glucose state by the WHO criteria (46.8%) than by the ADA criteria (22.3%).

Limitations

Several potential limitations of this study should be noted. First, our population was a selected group which represented a relatively young age, high socioeconomic status, high education and had a high level of stress. Second, we used only one baseline glucose measurement to classify individuals into glucose categories. Over time, many individuals who were normal, developed abnormal glucose concentration and vice versa.

SUMMARY

This study showed that the prevalence of impaired fasting glucose and diabetes mellitus in our population were 1.7 per cent and 0.8 per cent respectively. The prevalences were more common in males and with increasing age. Coronary risk factors such as high blood pressure, excessive weight and obesity, and abnormal lipid levels were more common in impaired fasting glucose even adjusted for age and sex. Progression to diabetes mellitus and whether or not impaired fasting glucose was associated with cardiovascular death need further study in a prospective fashion. Lifestyle modification in those with impaired fasting glucose may be needed for the prevention of coronary disease.

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การศึกษาระดับของปัจจัยเสี่ยงของโรคหลอดเลือดหัวใจใน Impaired fasting glucose (IFG) และโรคเบาหวาน

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คณะผู้วิจัยได้ทำการสำรวจหาความชุกของ impaired fasting glucose และโรคเบาหวานในกลุ่มพนักงานบริษัทชินวัตรจำนวน 3615 คน พบความชุกของ impaired fasting glucose และเบาหวานเท่ากับ 1.7% และ 0.8% ความชุกของ impaired fasting glucose และ เบาหวานพบมากกว่าในเพศชาย และความชุกสูงขึ้นตามอายุที่เพิ่มขึ้น การตรวจระดับของความดันโลหิต systolic, diastolic, pulse pressure, ดัชนี body mass index, รอบเอว, อัตราส่วนรอบเอว/รอบสะโพก, และระดับไขมัน cholesterol, triglyceride, และ LDL-cholesterol พบว่าใน impaired fasting glucose และเบาหวานสูงขึ้นกว่าในประชากรที่มีระดับน้ำตาลอยู่ในเกณฑ์ปกติ (ยกเว้น HDL-cholesterol) และระดับของปัจจัยเสี่ยงเหล่านี้ในคนที่เป็นเบาหวานสูงกว่าคนที่เป็น impaired fasting glucose (ยกเว้น pulse pressure ระดับ cholesterol, HDL- cholesterol และ LDL-cholesterol)

คำสำคัญ : Impaired Fasting Sugar, เบาหวาน, ปัจจัยเสี่ยงโรคหลอดเลือดหัวใจ

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