Type 2 Diabetes, Impaired Fasting Glucose, and Their Association with Increased Hepatic Enzyme Levels among the Employees in a University Hospital in Thailand

Wiroj Jiamjarasrangsi MD, PhD*, Somrat Lertmaharit MMed*,
Somkiat Sangwatanaroj MD, FRCP**, Vitool Lohsoonthorn MD, PhD*

** Department of Preventive and Social Medicine, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand*
*** Department of Internal, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand*

The purpose of the present study was to examine the association between abnormal hepatocellular functions and abnormal fasting glucose level in the employees in a university hospital in Bangkok, Thailand. A cross-sectional data analysis was conducted among 2,790 workers who were 35-60 years old and participated in both the annual fasting plasma glucose(FPG) examination and the baseline questionnaire survey during 2001-2005. The prevalence rates (95% confidence interval; CI) of impaired fasting glucose (IFG) were 10.4(9.1-11.7) and 20.3(17.0-23.9) percent respectively for women and men, while those of type 2 diabetes were 3.1(2.4-3.9) and 6.5 (4.6-8.9) respectively. After controlling for conventional risk factors, only the alanine aminotransferase (ALT) level was significantly associated with increased abnormal FPG. This association was particularly obvious for the DM. In conclusion, the present study demonstrated that the type 2 diabetes and ALT association was also evident in the Thai population.

Keywords: *Alanine transaminase, Aspartate aminotransferases, Diabetes mellitus, type 2, Glucose intolerance, Hospitals, university, Personnel, hospital*

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There is growing evidence about the association between abnormal hepatocellular functions and type 2 diabetes. A number of studies have found that high levels of hepatic enzymes, including alanine aminotransferase (ALT), aspartate aminotransferase (AST), and γ-glutamyltranspeptidase (GGT) are associated with the development of diabetes[1-10]. These enzymes, particularly ALT, are elevated in non-alcoholic fatty liver disease (NAFLD)[11]. Recent studies suggested that hyperinsulinemia and insulin resistance may play a role in the pathogenesis of both type 2 diabetes and NAFLD. However, the association patterns between elevated liver enzymes and type 2 diabetes are complex and not consistent across different studies[12]. Furthermore, the majority of the evidence arose from Western countries, and relatively little evidence was available for the Asian population[6,7].

The purpose of the present study was to examine the association between abnormal hepatocellular functions and type 2 diabetes among the Thai population. Its specific aims were: (a) to determine the prevalence of type 2 diabetes and impaired fasting glucose and; (b) their association with conventional cardiovascular risk factors and biochemical parameters.

Correspondence to: Jiamjarasrangsi W, Department of Preventive and Social Medicine, Faculty of Medicine, Chulalongkorn University, Pathumwan, Bangkok 10330, Thailand. E-mail: wjiamja@gmail.com

Material and Method

Study population

The present study was a cross-sectional part of a longitudinal study on the health of the employees in a university hospital in Bangkok, Thailand. This hospital contained 1,200 beds and employed totally 5,000 workers in 2001. As the annual fasting plasma

glucose was offered only for workers who were 35 years of age or older, the target population for this analysis was those who were 35+ years old during 2001-2005.

Survey procedure

Personal demographic data (such as gender, date of birth, educational level) were obtained from the computerized database of the hospital. Additional information about the individual's personal and family history of disease, cigarette smoking and alcoholic consumption was obtained by a questionnaire survey which was conducted once in 2003.

Baseline health examination was conducted during 2001-2005. Totally 494 (17.4 percent), 1,307 (46.0 percent), 371 (13.1 percent), 459 (16.1 percent), and 159 (5.6 percent) employees were first examined consecutively during this period. After an overnight fast, the participants underwent the anthropometric measurements and blood samples. Weight, height, and blood pressure (in the sitting position) were measured by staff nurses. Fasting plasma glucose, serum total cholesterol, triglycerides, uric acid, blood urea nitrogen (BUN), creatinine, alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP) were measured in a standardized manner at the biomedical laboratory of the hospital.

Definitions

Diagnosis of diabetes was defined according to the American Diabetic Association (ADA) criteria, *i.e.* when FPG level was ≥ 126 mg/dl (7.0 mmol/l) or having a history of physician diagnosed diabetes or those who were on treatment, For impaired fasting glucose (IFG) or pre-diabetes was defined as those with FPG levels ≥ 100 mg/dl (5.6 mmol/l) but < 126 mg/dl (7.0 mmol/l)[13].

Body mass index (BMI) was calculated as (weight in kg)/(height in meters)^2. Physical status of individuals was classified based on the BMI as: underweight for BMI < 18.5 kg/m^2; normal for BMI 18.5-22.9 kg/m^2; overweight for BMI 23.0-27.5 kg/m^2, and; obesity for BMI ≥ 27.5 kg/m^2[14].

Blood pressure was classified as normal (systolic blood pressure or SBP < 120 mmHg and diastolic blood pressure or DBP < 80 mmHg), pre-hypertension (SBP = 120-139 or DBP = 80-89 mmHg), stage 1 hypertension (SBP = 140-159 or DBP = 90-99 mmHg), or stage 2 hypertension (SBP ≥ 160 or DBP ≥ 100 mmHg) according to the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-7)[15]. Total serum cholesterol level was categorized into desirable (< 200 mg/dl), borderline high (200-239 mg/dl), or high (≥ 240 mg/dl); and triglyceride was categorized into normal (< 150 mg/dl), borderline (150-199 mg/dl), high (200-499 mg/dl), and very high (≥ 500 mg/dl) according to the Third Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (ATP III)[16]. Serum uric acid, BUN, creatinine, AST, ALT and ALP were classified into normal or high by using the cut points of 7,20,1.3,38,38 and 117 mg/dl respectively for these biochemical parameters. In addition, the normal ranges of these parameters were further categorized into quartile to facilitate detailed examination about the associations between these parameters and abnormal plasma glucose levels.

Statistical analysis

Age-group specific prevalence rates of type 2 diabetes and IFG, as well as their corresponding 95% confidence intervals (CIs) were calculated seperately for both gender. In the comparison among the normal, IFG and type 2 diabetes groups, means (95% CIs), medians (5th and 95th percentiles), or proportions (95% CIs) were calculated for continuous variables with normal or skewed distributions, or categorical variables respectively. The test for trend described by Cuzick was then used to assess the significant difference for these variables across the ordered FPG groups (normal, IFG, and diabetes)[17]. Separated multivariable logistic regression models were used to assess the associations of abnormal fasting plasma glucose status (normal versus IFG or type 2 diabetes; dependent variables) and anthropometric measures, physiological and biochemical parameter (independent variables). Backward selection procedures were used in the statistical modeling. Variables with p-value < 0.2 were eligible for addition into the modeling procedures, and p-value of < 0.05 was the cut-off for the statistically significant level[18]. Adjusted odds ratios (95% CI) were presented for the final models.

Results

Subject characteristics

Of all 3,243 workers who were 35-60 years old and eligible for the annual fasting glucose examination during 2001-2005, only 2,097 workers (64.7 percent) participated in both the health examination and baseline questionnaire survey, while 693 workers (21.4 percent) participated only in the baseline health examination. These two worker groups were included

in this analysis and amounted to 86.0 percent of the target population. Among all these 2,790 workers, 2,239 (80.3 percent) were women and 551(19.7 percent) were men. Their mean age was 42.7 $\pm$ 7.6 years with average working duration of 18.1 $\pm$ 7.7 years.

Prevalence of abnormal plasma glucose

Table 1 shows the prevalence of abnormal FPG levels stratified by age-group and gender. The overall prevalence rates of IFG and type 2 diabetes were approximately twice higher among men than women. Increased IFG and type 2 diabetes prevalence rates according to increased age were more obvious among women (except for the lowest and highest age-groups), probably due to larger sample size.

Cardiovascular risk profile

There were significant trends in the increases of almost all demographic, physiological, and biochemical parameters across the ordered FPG groups (normal, IFG, and diabetes) in both genders, except for the serum creatinine level in women and serum BUN, creatinine, uric acid and ALP levels in men (Tables 2 and 3 respectively for both genders). The frequencies of diabetes history in the family were significantly increases across the FPG groups in both genders. There also seemed to be the inverse relationship between educational levels and abnormal FPG levels.

Among the hepatic enzymes, although the trends of increases across the FPG groups were statistically significant for all enzymes, those for the ALT level were most obvious in both genders, while those trends for the AST and ALP were obvious only in women.

Prevalence of increased hepatic enzyme levels

Table 4 shows that the prevalence rates of abnormally high hepatic enzyme levels increase in stepwise manner across the FPG groups except for the prevalence of high ALP levels in men, probably due to the small sample size in the group of type 2 diabetes men. Results also showed that the prevalence rates of abnormal ALT and AST were approximately 2-5 times higher among men than women. The highest difference was the prevalence rates of abnormal ALT in the normal FPG groups, which was 4.7 times higher for men than women. The gender difference in the prevalence rates of abnormal ALP levels was not consistent.

Association between hepatic enzyme levels and abnormal FPG status

After controlling for conventional risk factors, only the ALT significantly was associated with increased abnormal FPG. This association was particularly obvious for the DM, although the dose-response pattern seemed to occur for both the IFG and diabetes risk (Table 5).

Besides, the multivariable analytical results also showed that the hypertension status significantly associated with abnormal FPG in both the IFG and diabetes groups (Table 5). Men had significantly increased risk only for IFG, but not for diabetes. Increased abnormal FPG risks according to age were obvious, although the statistical significance had been attained only in the 50-59 age range. Significantly increased risk due to family history of diabetes was shown only for the diabetes but not for the IFG. Concerning the BMI, only the obese status was significantly associated with diabetes risk.

Table 1. Prevalence of abnormal plasma glucose according to age and gender

Age-group (yr)	Female					Male				
	Total (n)	IFG		Diabetes		Total (n)	IFG		Diabetes	
		%	(95% CI)	%	(95% CI)		%	(95% CI)	%	(95% CI)
35-39	737	4.3	(2.9-6.1)	1.4	(0.7-2.5)	182	16.5	(11.4-22.7)	0.6	(0.0-3.1)
40-44	563	8.0	(5.9-10.5)	2.1	(1.1-3.7)	141	20.6	(14.2-28.2)	5.7	(2.5-10.9)
45-49	360	10.8	(7.8-14.5)	3.1	(1.5-5.4)	96	17.7	(10.7-26.8)	13.5	(7.4-22.0)
50-54	355	19.2	(15.2-23.6)	5.9	(3.7-8.9)	75	30.7	(20.5-42.4)	8.0	(3.0-16.6)
55-59	199	22.1	(16.5-28.5)	7.0	(3.9-11.5)	49	22.4	(11.8-36.6)	10.2	(3.4-22.2)
60+	25	16.0	(4.5-36.1)	4.0	(0.1-20.4)	8	25.0	(3.2-65.1)	37.5	(8.5-75.5)
Total	2,239	10.4	(9.1-11.7)	3.1	(2.4-3.9)	551	20.3	(17.0-23.9)	6.5	(4.6-8.9)

IFG = impaired fasting plasma glucose

Table 2. Baseline clinical and metabolic parameters according to plasma glucose levels (women)

Parameters	Normal (n = 1,938)		IFG (n = 232)		Type 2 diabetes (n = 69)		Test for trend
	Mean	95% CI	Mean	95% CI	Mean	95% CI	
Age (yr)	42	(35-56)	49.5	(36-58)	50	(36-59)	<0.05
BMI (kg/m^2)	23.3	(23.2-23.5)	25.5	(24.9-26.1)	27.6	(26.4-28.8)	<0.05
SBP (mmHg)	118.6	(117.9-119.3)	129.8	(127.4-132.2)	134.6	(129.5-139.6)	<0.05
DBP (mmHg)	69.8	(69.3-70.3)	74.0	(72.5-75.5)	78.3	(75.4-81.2)	<0.05
Cholesterol (mg/dl)	209.5	(207.8-211.2)	230.3	(224.3-236.3)	229.6	(218.3-240.8)	<0.05
Triglyceride (mg/dl)	81	(41-192)	101	(46-295)	143	(70-347)	<0.05
BUN (mg/dl)	11.7	(11.6-11.9)	12.2	(11.7-12.6)	12.4	(11.7-13.2)	<0.05
Cr (mg/dl)	0.7	(0.7-0.7)	0.7	(0.7-0.7)	0.7	(0.7-0.8)	ns
Uric acid (mg/dl)	4.4	(4.4-4.5)	4.9	(4.8-5.1)	5.1	(4.8-5.5)	<0.05
AST (U/l)*	19	(14-33)	20	(14-45)	21	(14-47)	<0.05
ALT (U/l)*	15	(8-39)	20	(10-65)	25	(11-69)	<0.05
AST to ALT ratio	1.2	0.7-2.1)	1.0	(0.6-2.0)	0.9	(0.6-1.6)	<0.05
ALP (U/l)*	61	(38-98)	70	(41-119)	72	(51-119)	<0.05
	Percent	95%CI	Percent	95%CI	Percent	95%CI	
Smoking	0.3	(0.1-0.6)	0.9	(0.1-3.1)	0.0	(0.0-0.0)	ns
Alcohol drinking	29.2	(27.2-31.3)	29.7	(23.9-36.1)	31.9	(21.2-44.2)	ns
Family history of DM	17.6	(16.0-19.4)	23.3	(18.0-29.3)	26.1	(16.3-38.1)	<0.05
Education							
Primary	14.6	(13.1-16.3)	23.7	(18.4-29.7)	21.7	(12.7-33.3)	<0.05
Secondary	27.0	(25.1-29.1)	22.0	(16.8-27.9)	36.2	(25.0-48.7)	ns
Professional	33.1	(31.0-35.3)	36.2	(30.0-42.8)	31.9	(21.2-44.2)	ns
Bachelor+	22.1	(20.3-24.1)	14.2	(10.0-19.4)	7.2	(2.4-16.1)	<0.05
Undefined	3.1	(2.4-4.0)	3.9	(1.8-7.2)	2.9	(0.4-10.1)	ns

* Median $\pm$ interquartile range was shown instead of mean $\pm$ standard deviation
ns = not statistically significance
BMI = body mass index, SBP = systolic blood pressure, DBP = diastolic blood pressure, BUN = blood urea nitrogen, Cr = creatinine, AST = aspartate aminotransferase, ALT = alanine aminotransferase, ALP = alkaline phosphatase, IFG = impaired fasting plasma glucose

Concerning the lipid levels, the total cholesterol was only significantly associated with IFG risk, while the triglyceride level was significantly associated with the diabetes risk in the dose-response manner.

Discussion

In the present study, the authors showed the rates of abnormal fasting plasma glucose and type 2 diabetes and their cross-sectional association with ALT among predominantly female employees in a university hospital in Bangkok, Thailand. The definition of both IFG and diabetes among this worker group were described based on the most up to date diagnostic criteria according to the ADA.

Comparing to the recent national survey, the authors' reported IFG and diabetes prevalence rates were significantly lower than the surveyed Bangkok population, except for the IFG prevalence rate of 20.3 percent among the male employees, which was slightly higher than the national survey result (the diabetes prevalence rates among male and female Bangkok population in 2003-2004 were 12.4 and 14.6 percent, and the IFG prevalence rates among these population subgroups were 17.4 and 14.6 percent respectively)[19]. This might be due to the studied employees being healthier than the survey population.

Concerning to the association between liver enzymes and abnormal FPG, the present study showed a significant association between the ALT and type 2 diabetes with an obvious dose-response pattern,

Table 3. Baseline clinical and metabolic parameters according to plasma glucose levels (men)

Parameters	Normal (n = 403)		IFG (n = 112)		Type 2 diabetes (n = 36)		Test for trend
	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	
Age (yr)*	42	(35-56)	44	(35-58)	48	(40-62)	<0.05
BMI (kg/m2)	24.1	(23.7-24.4)	24.9	(24.2-25.7)	26.9	(25.6-28.2)	<0.05
SBP (mmHg)	126.1	(124.5-127.7)	135.2	(131.6-138.9)	138.9	(133.1-144.6)	<0.05
DBP (mmHg)	76.4	(75.3-77.5)	81.6	(79.1-84.0)	81.7	(78.2-85.2)	<0.05
Cholesterol (mg/dl)	213.1	(209.4-216.8)	227.3	(219.8-234.7)	221.2	(208.3-234.2)	<0.05
Triglyceride (mg/dl)	120	(52-347)	154	(65-399)	175	(48-369)	<0.05
BUN (mg/dl)	13.3	(13.0-13.7)	14.2	(13.5-14.9)	12.7	(11.6-13.7)	ns
Cr (mg/dl)	1.0	(0.9-1.0)	0.9	(0.9-1.0)	0.9	(0.9-1.0)	ns
Uric acid (mg/dl)	6.3	(6.1-6.4)	6.5	(6.3-6.8)	5.8	(5.4-6.3)	ns
AST (U/l)*	24	(16-50)	26.5	(16-89)	26	(17-57)	<0.05
ALT (U/l)*	26	(13-77)	30.5	(14-101)	37.5	(17-103)	<0.05
AST to ALT ratio	0.9	(0.5-1.7)	0.9	(0.4-1.7)	0.7	(0.4-1.8)	<0.05
ALP (U/l)*	69	(47-107)	65	(44-120)	78	(49-114)	ns
	Percent	95% CI	Percent	95% CI	Percent	95% CI	
Smoking	18.4	(14.7-22.5)	24.1	(16.5-33.1)	11.1	(3.1-26.1)	ns
Alcohol drinking	73.2	(68.6-77.5)	76.8	(67.9-84.2)	61.1	(43.5-76.9)	ns
Family history of DM	8.4	(5.9-11.6)	9.8	(5.0-16.9)	30.6	(16.3-48.1)	<0.05
Education							
Primary	43.9	(39.0-48.9)	52.7	(43.0-62.2)	61.1	(43.5-76.9)	<0.05
Secondary	34.5	(29.9-39.4)	24.1	(16.5-33.1)	11.1	(3.1-26.1)	<0.05
Professional	15.1	(11.8-19.0)	18.8	(12.0-27.2)	25.0	(12.1-42.2)	ns
Bachelor+	4.5	(2.7-7.0)	1.8	(0.2-6.3)	0.0	(0.0-0.0)	ns
Undefined	2.0	(0.9-3.9)	2.7	(0.6-7.6)	2.8	(0.1-14.5)	ns

* Median ± interquartile range was shown instead of mean ± standard deviation
ns = not statistically significance
BMI = body mass index, SBP = systolic blood pressure, DBP = diastolic blood pressure, BUN = blood urea nitrogen, Cr = creatinine, AST = aspartate aminotransferase, ALT = alanine aminotransferase, ALP = alkaline phosphatase, IFG = impaired fasting plasma glucose

Table 4. Prevalence rates of abnormal hepatic enzymes according to fasting plasma glucose groups, stratified by gender

Hepatic enzyme level	Normal		IFG		Type 2 diabetes		Test for trend
	Percent	(95% CI)	Percent	(95% CI)	Percent	(95% CI)	
Men							
AST > 36 mg/dl	10.7	(7.8-14.1)	17.0	(10.5-25.2)	25.0	(12.1-42.2)	<0.05
ALT > 36 mg/dl	23.9	(19.8-28.4)	38.4	(29.4-48.1)	47.2	(30.4-64.5)	<0.05
ALP > 117 mg/dl	2.2	(1.0-4.2)	5.4	(2.0-11.3)	2.8	(0.1-14.5)	ns
Women							
AST > 36 mg/dl	2.6	(1.9-3.4)	7.8	(4.7-12.0)	10.1	(4.2-19.8)	<0.05
ALT > 36 mg/dl	5.1	(4.2-6.2)	17.3	(12.7-22.8)	18.8	(10.4-30.1)	<0.05
ALP > 117 mg/dl	1.6	(1.1-2.2)	5.6	(3.0-9.4)	5.8	(1.6-14.2)	<0.05

ns = not statistically significance
AST = aspartate aminotransferase, ALT = alanine aminotransferase, ALP = alkaline phosphatase, IFG = impaired fasting plasma glucose

Table 5. Adjusted odds ratios (ORs) for impaired fasting glucose (IFG) and type 2 diabetes

Characteristics	Normal vs. IFG			Normal vs. diabetes		
	OR	(95% CI)	p-value	OR	(95% CI)	p-value
Gender						
Female	1.0					
Male	1.6	(1.2-2.1)	<0.005	1.1	(0.7-1.9)	ns
Age (yr)						
30-34	0.6	(0.1-2.8)	ns	2.8	(0.3-23.4)	ns
35-39	1.0					
40-44	1.4	(1.0-2.1)	ns	1.8	(0.8-4.0)	ns
45-49	1.4	(1.0-2.2)	ns	2.7	(1.2-6.0)	<0.05
50-54	2.7	(1.9-4.0)	<0.001	3.3	(1.5-7.3)	<0.005
55-59	2.9	(1.8-4.5)	<0.001	3.7	(1.6-8.7)	<0.005
60-64	2.4	(0.9-6.4)	ns	6.2	(1.7-22.9)	<0.01
Family history of diabetes						
No				1.0		
Yes	1.3	(0.9-1.8)	ns	2.2	(1.4-3.6)	<0.005
BMI(kg/m^2)						
≤ 18.4	1.3	(0.7-2.6)	ns	0.9	(0.1-7.1)	ns
18.5-22.9	1.0					
23.0-27.4	1.0	(0.8-1.4)	ns	1.8	(1.0-3.5)	ns
≥ 27.5	1.4	(1.0-2.1)	ns	3.2	(1.6-6.4)	<0.001
SBP and/or DBP (mmHg)						
< 120 & < 80	1.0			1.0		
120-139 or 80-89	1.7	(1.2-2.3)	<0.005	3.0	(1.4-6.3)	<0.005
140-159 or 90-99	2.4	(1.6-3.5)	<0.001	3.4	(1.5-7.6)	<0.005
≥ 160 or ≥ 100	3.1	(1.8-5.3)	<0.001	5.4	(2.1-13.9)	<0.001
Total cholesterol (mg/dl)						
< 200	1.0			1.0		
200-239	1.6	(1.2-2.2)	<0.005	0.7	(0.4-1.2)	ns
≥ 240	2.0	(1.4-2.8)	<0.001	1.1	(0.6-1.9)	ns
Triglyceride (mg/dl)						
<150	1.0			1.0		
150-199	0.9	(0.6-1.3)	ns	1.6	(0.9-2.8)	ns
200-499	1.4	(1.0-2.1)	ns	2.0	(1.1-3.6)	<0.05
≥ 500	3.4	(1.0-11.5)	ns	5.5	(1.1-27.9)	<0.05
ALT quartile (mg/dl)						
Quartile 1 (1-12)	1.0			1.0		
Quartile 2 (13-16)	1.1	(0.7-1.6)	ns	1.0	(0.3-3.5)	ns
Quartile 3 (17-22)	1.1	(0.7-1.7)	ns	3.1	(1.1-8.4)	<0.05
Quartile 4 (23-38)	1.4	(0.9-2.1)	ns	3.9	(1.4-10.5)	<0.01
High (> 38)	2.4	(1.5-3.8)	<0.001	5.5	(2.0-15.6)	<0.005

ns = not statistically significance
BMI = body mass index, SBP = systolic blood pressure, DBP = diastolic blood pressure, ALT = alanine aminotransferase, IFG = impaired fasting plasma glucose

while the ALT and IFG association was obvious only in the group with highest ALT compared to the lowest quartile group. The authors found no significant association between AST or ALP and abnormal FPG levels. This was consistent with studies conducted by Vozarova et al in Pima Indians[10], Nannipieri et al Mexico[5], Wannamethee et al in the United Kingdom[3], and other studies conducted recently[20,21].

Some limitations, however, needed to be mentioned in the present study. The authors did not collect information about hepatitis B and C infection, alcohol consumption, and physical activity from the

subjects. So confounding effects of these factors could not be excluded from the presented interpretation. However, as the present findings were consistent with many other studies conducted previously, their confounded effect might be minimal.

In conclusion, the authors reported IFG and diabetes prevalence rates among a university hospital in Bangkok were significantly lower than the surveyed Bangkok population. In addition, the authors demonstrated that the type 2 diabetes and ALT association was also evidenced in the Thai population.

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โรคเบาหวานชนิดที่ 2, ระดับพลาสมากลูโคสเมื่อออดอาหารผิดปกติ และความสัมพันธ์กับระดับเอนไซม์ของตับสูงขึ้นในลูกจ้างโรงพยาบาลมหาวิทยาลัยแห่งหนึ่งในประเทศไทย

วิโรจน์ เจียมจรัสรังษี, สมรัตน์ เลิศมหาฤทธิ์, สมเกียรติ แสงวัฒนาโรจน์, วิฑูรย์ โล่ห์สุนทร

การศึกษานี้มีวัตถุประสงค์เพื่อหาความสัมพันธ์ระหว่างระดับเอ็นไซม์ตับผิดปกติและระดับน้ำตาลใน เลือดผิดปกติในเจ้าหน้าที่โรงพยาบาลมหาวิทยาลัยแห่งหนึ่งในกรุงเทพมหานคร โดยทำการศึกษาภาคตัดขวางในเจ้าหน้าที่จำนวน 2,790 คนที่มีอายุระหว่าง 35-60 ปีที่ร่วมในการตรวจระดับน้ำตาลในเลือดและตอบแบบสำรวจในช่วงปี พ.ศ. 2544-2548 พบว่าอัตราชุก (ค่าความเชื่อมั่นที่ร้อยละ 95) ของภาวะก่อนเบาหวานในหญิงและชายเท่ากับร้อยละ 10.4 (9.1-11.7) และ 20.3 (17.0-23.9) ตามลำดับ ขณะที่อัตราชุก (ค่าความเชื่อมั่นที่ร้อยละ 95) ของโรคเบาหวานชนิดที่ 2 ของกลุ่มตัวอย่างทั้งสองเพศเท่ากับร้อยละ 3.1 (2.4-3.9) และ 6.5 (4.6-8.9) ตามลำดับ หลังจากควบคุมตัวกวนแล้วพบว่ามีเพียงระดับเอ็นไซม์ Alanine aminotransferase (ALT) เท่านั้นที่มีความสัมพันธ์อย่างมีนัยสำคัญทางสถิติกับระดับน้ำตาลในเลือดผิดปกติ โดยเฉพาะกับโรคเบาหวาน โดยสรุป การศึกษานี้แสดงให้เห็นความสัมพันธ์ระหว่างระดับ ALT ผิดปกติกับโรคเบาหวานชนิดที่ 2 ในประชากรไทยเช่นเดียวกับการศึกษาในเชื้อชาติอื่น ๆ