Undiagnosed Diabetes Mellitus in Taiwanese Subjects with Impaired Fasting Glycemia: Impact of Female Sex, Central Obesity, and Short Stature

W.-H. Pan[1,2], W.-T. Yeh[1], C.-M. Hwu[3] and L.-T. Ho[4]

[1]*Institute of Biomedical Sciences*
Academia Sinica
Taipei, Taiwan
[2]*Graduate Institute of Epidemiology*
College of Public Health, National Taiwan University
Taipei, Taiwan
[3]*Section of General Medicine*
Department of Medicine, Veterans General Hospital-Taipei
Taipei, Taiwan
[4]*Section of Endocrinology and Metabolism, Department of Medicine*
Veterans General Hospital-Taipei
Taipei 112, Taiwan

Abstract

AIMS – To study the extent and determinants of undiagnosed diabetes mellitus (DM) in Taiwanese subjects with impaired fasting glycemia (IFG) defined by the newly proposed WHO criteria.

METHODS – Oral glucose tolerance tests were carried out for 306 IFG subjects identified from 6632 adult participants of two large scale community-based studies: Nutrition and Health Survey in Taiwan (1993-1996) and the Cardiovascular Disease Two-township Study (1994-1997). Similar protocols were used in these two studies to collect data on glycemic status, anthropometric measurements, and other data used in the present study.

RESULTS – Subjects with IFG had a non-trivial undiagnosed diabetes mellitus rate (30% in men and 42% in women) and a high rate of glucose intolerance and undiagnosed DM combined (75 % in men and 86 % in women). Women with IFG had a 1.6 fold higher risk ($p = 0.04$) for undiagnosed DM and a 2.1 fold higher risk ($p = 0.01$) for glucose intolerance and DM when compared to men. There were more women than men with an elevated body mass index in undiagnosed DM patients. Among IFG subjects, undiagnosed DM patients were significantly ($p < 0.05$) older, more centrally obese and shorter than their normal IFG counterparts, irrespective of gender. In men, height was independent of age and waist circumference in predicting undiagnosed DM ($p = 0.037$).

CONCLUSIONS – A high proportion of impaired glucose tolerance and undiagnosed DM was found in subjects with IFG. Its public health impact should not be overlooked. Central obesity, female sex, and short stature were associated with undiagnosed DM status in IFG subjects.

Key Words: undiagnosed diabetes mellitus, impaired fasting glycemia, women, central obesity, height

Introduction

Diabetes mellitus (DM) is an emerging health problem in Taiwan and in many parts of the world (1). Using the criteria proposed by WHO (2), a prevalence of 3.2% percent in men and a prevalence of 5.5% in

Corresponding author: Dr. Wen-Harn Pan, Institute of Biomedical Sciences, Academia Sinica, Taipei 112, Taiwan, ROC. Tel: 886-2-26523042, Fax: 886-2-27823047, E-mail: pan@ibms.sinica.edu.tw
Received February 5, 2001; Revised March 6, 2001; Accepted March 7, 2001.

women aged 19 and above was found in the Nutrition and Health Survey in Taiwan (NAHSIT 1993-1996) (3). Our more recent study on DM incidence in Taiwan showed that the age-standardized annual incidence was as high as 9 per 1,000, for those aged 35-74 (4). In addition, DM mortality ranked as the fifth leading cause of death in Taiwan since 1998. It has increased at a doubling rate and recently become the third leading cause of death in women (5). Accurately diagnosing DM patients and providing lifestyle modification measures and treatments are essential to reversing DM and to preventing the adverse consequences of this disorder.

Patients with undiagnosed DM are at very high risk for micro- and macrovascular complications (6). Mortality in undiagnosed DM is as high as that observed in known DM, and mortality in both is significantly higher than in non-diabetic individuals (7-8). The major aim of the present study was to examine the extent of undiagnosed DM in Taiwanese with impaired fasting hyperglycemia (IFG), using the current proposed criteria by WHO, and to determine the demographic and anthropometric determinants of this condition.

Materials and Methods

Research Design

To address the issue of undiagnosed diabetes mellitus in Taiwan, we used data collected from two previous large scale studies. The first set of data is from the Nutrition and Health Survey in Taiwan (NAHSIT, 1993-1996), a national nutrition survey with a multistage, stratified and clustered sampling scheme (9-10). A standardized and structured questionnaire was administered to collect detailed demographic data, past medical history and history of medication along with other nutrition related questionnaires. A response rate of 74% was obtained for the household interviews. Around 62% of those interviewed have participated the physical examinations. Following an overnight fast of 8 hours or more, subjects reported to the local clinical research station in the morning for physical examinations. The survey target included individuals age 4 and above. There were 2,676 participants (1,258 men and 1,418 women) aged 20 and above interviewed and physically examined.

The second is from the baseline data (1994-1997) of the Cardiovascular Disease Risk Factor Two-township Study (CVDFACTS) (11), which was a longitudinal study of risk factors, incidence, and sub-clinical disorders of the cardiovascular diseases, carried out in Chu-Dung township and Pu-Tzu township of Taiwan. Recruitment had been made to all residents of five selected villages by sending out up to three invitation letters to the households. In this study, baseline data on glycemic status and anthropometric parameters were derived from 1786 men and 2170 women aged 20 and above.

Data Collection

NAHSIT and CVDFACTS used the same protocol for measuring anthropometric parameters and bioelectrical impedance (BIA), and similar procedures for measuring hyperglycemia. Informed consent was obtained from participants of both studies.

Fasting Blood Glucose

A fasting venous whole blood sample was collected in a NaF tube. In NAHSIT, whole blood glucose (WBG) was immediately measured by the glucose oxidase method using a glucose analyzer (Model 23A, YSI, U.S.A.). In CVDFACTS, plasma glucose (PG) was measured within one month of blood collection by the glucose oxidase method using an automatic analyzer (Hatachi 705, OLYMPUS). Subjects treated with DM drugs were considered as patients of known DM. For subjects without known DM, fasting glucose were measured. Subjects with 5.6 mM ≤ WBG < 10.0 mM or 6.1 mM ≤ PG < 11.1 mM received a 75 g oral glucose tolerance test (OGTT).

Oral Glucose Tolerance Test

The procedures for OGTT were carried out as previously described (12). In brief, subjects received 75 g glucose monohydrate (in 250 ml water) within 6 AM - 11 AM after a fast of 8 hours or more. Subjects remained in a sitting position throughout the study. Smoking and eating were not allowed. Blood samples were drawn into NaF tubes right before and at 30, 60, 90 and 120 minutes after glucose loading. In NAHSIT, WBG concentrations were determined immediately by the glucose oxidase method using a glucose analyzer (Model 23A, YSI, U.S.A.). In CVDFACTS, PG was measured within a month of blood collection by the glucose oxidase method using an automatic analyzer (Hatachi 705, OLYMPUS).

Anthropometric Measurements

Anthropometric measurements were carried out after subjects had removed their shoes and heavy clothes. Subjects were asked to put on an examining gown if their apparel was not appropriate for taking

measurements. Body weight was measured to the nearest 0.1 Kg, and body height to the nearest millimeter. Body mass index (BMI) was calculated as weight divided by height squared (Kg/M^2). Waist circumference was measured horizontally at the level of the natural waist, which was identified as the level at the hollow molding of the trunk when the trunk was concaved laterally. Hip circumference was measured horizontally at the level of the greater trochanters. Waist hip ratio(WHR) was calculated as waist circumference divided by hip circumference. BMI is an index of general obesity. Waist circumference, WHR, and subscapular skinfold thickness are indices of central obesity. Triceps and subscapular skinfold thickness were measured twice in mm to one decimal place by Lange skinfold calipers (Cambridge scientific industries, INC., Cambridge, Maryland, U.S.A.), and the averaged data used in the analysis. Triceps skinfold measurements were taken midway between the acromion and the olecranon in the mid-line of the posterior surface of the right upper arm. Subscapular skinfold thickness was measured at one centimeter below the tip of the right scapular, with the arm positioned parallel to trunk.

Bioelectric Impedance Analysis

Whole body BIA was performed on subjects using a portable impedance analyzer (SIF-891, Selco, Tokyo, Japan). Measurements were performed while subjects were in a supine position with limbs abducted from the body at about 30 degrees. Current injector electrodes were placed just below the phalangeal-metacarpal joint in the middle of the right hand and just below the transverse arch on the superior side of the right foot. Detector electrodes were placed on the posterior aspect of the right wrist and the ventral side of the right ankle. The analyzer provided a 50 kHz, 800 μamp current. Reactance (expressed in ohms) and resistance (in ohms) were recorded. Body fat percentages (fat%) were calculated from Nakadomo's equation (13).

Statistical Analysis

In the present study, diabetes mellitus was defined as fasting WBG ≥ 6.1 mM or PG ≥ 7.0 mM according to the recommendation of the Provisional Report of WHO consultation on Diagnosis and Classification of Diabetes Mellitus (2). Impaired fasting glycemia (IFG) was defined as 5.6 mM ≤ fasting WBG < 6.1 mM or 6.1 mM ≤ fasting PG < 7.0 mM. The IFG subjects were further divided into three subgroups according to the 2-hour glucose level of the OGTT. The IFG normal group had a post-challenge glucose level of less than 6.7 mM of WBG or 7.8 mM of PG. The IFG-impaired glucose tolerance (IFG-IGT) group had 6.7 mM ≤ post-challenge WBG < 10.0 mM or 7.8 mM ≤ post-challenge PG < 11.1 mM. IFG-OGTT+ group had post-challenge WBG ≥ 10.0 mM or PG ≥ 11.1 mM. For each of the above cases, a normal glycemic (WBG < 5.6 mM or PG < 6.1 mM) subject from the same study was matched by age, sex and residential area to form a normal control group. Anthropometric data were expressed as mean ± standard deviation (SD) and compared among normal controls, diabetic patients and three IFG groups: IFG-DM, IFG-IGT, and IFG-normal. Duncan analysis was used to compare the means of obesity indices among groups in men and women separately. Those who refused to take the OGTT and those who were taking diabetic medicine were excluded from this analysis.

Chi-square test was used to compare the rates of undiagnosed DM (or glucose intolerance/DM) between male and female subjects and the rates of obesity between undiagnosed DM and non-DM subjects. The BMI cut-point of 28.6 Kg/M^2 was used to define obesity, which was the median value of the studied sample.

Multivariate logistic regression was carried out to study jointly the effects of age, height, and obesity indices on DM status. Statistical package SAS, version 6.12 was used for the above analyses.

Results

Among 2676 NAHSIT subjects (1258 men and 1418 women) and 3956 CVDFACTS subjects (1786 men and 2170 women) aged 20 and above not taking DM medication, 422 were in the range of 6.1 mM ≤ fasting PG < 7.0 mM (or 5.6 mM ≤ fasting WBG < 6.1 mM), 145 were in the range of 7.0 mM ≤ fasting PG < 7.8 (or 6.1 mM ≤ fasting WBG < 6.7 mM), and 233 were in the range of 7.8 mM ≤ fasting PG < 11.1 mM (or 6.7 mM ≤ fasting WBG < 10.0 mM). There were 306 (73%), 92 (63%), and 74 (32%) subjects in each of the three ranges, respectively, willing to take the OGTT.

Proportion of Undiagnosed DM in Various Glycemic Groups

Table 1 shows the distribution of OGTT positive (OGTT+) and impaired glucose tolerance (IGT) in IFG subjects, and in subjects with 7.0 (6.1) mM ≤ fasting PG (WBG) < 7.8 (6.7) mM, and 7.8 (6.7) mM ≤ fasting PG (WBG) < 11.1 (10.0) mM. In IFG subjects, there were 30% OGTT+ men and 42% OGTT+ women. In subjects with 7.0 (6.1) mM ≤ fasting PG (WBG) < 7.8 (6.7) mM, there were 46% OGTT+ men and 75% OGTT+ women. In subjects

Table 1. Distribution of OGTT Positive and/or IGT Status and Obesity Status by Three Fasting WBG Ranges

	Fasting PG/WBG (mM)					
	6.1 ≤ PG < 7.0 5.6 ≤ WBG < 6.1		7.0 ≤ PG < 7.8 6.1 ≤ WBG < 6.7		7.8 ≤ PG < 11.1 6.7 ≤WBG < 10.0	
	men	women	men	women	men	women
N of OGTT	152	154	35	57	37	37
N of OGTT+	46	64	16	43	30	32
% of OGTT+	30%	42%	46%	75%	81%	86%
OR for OGTT+ Women vs. men[a]	1.6 (p=0.04)		3.6 (p=0.004)		1.5 (p=0.53)	
N of IGT	68	69	12	11	3	4
% of IGT	45%	45%	34%	19%	8%	11%
N of IGT or OGTT+	114	133	28	54	33	36
% of IGT or OGTT+	75%	86%	80%	95%	89%	97%
OR for IGT and OGTT+ Women vs. men[a]	2.1 (p=0.01)		4.5 (p=0.03)		4.4 (p=0.17)	
% with high BMI[b]	13.2%	26%	8.6%	35.1%	10.8%	40.5%

[a]Odds ratio (p-value)
[b]BMI≥28.6

with 7.8 (6.7) mM ≤ fasting PG (WBG) < 11.1 (10.0) mM, there were 81% OGTT+ men and 86% OGTT+ women. The lower the fasting PG/WBG level, the smaller the percentage of those with OGTT+.

Effect of Gender on the Risk of Undiagnosed DM

As shown in Table 1, there were more OGTT+ women than men in each of the fasting WBG ranges, indicating a gender effect on glucose intolerance. Using BMI ≥ 28.6 as the obesity criteria, there were also more obese women than men in each PG/WBG range. IFG women had a significant 1.6 fold risk for undiagnosed DM (OGTT+) and a significant 2.1 fold risk for glucose intolerance (IGT or OGTT+) compared to IFG men. A stronger gender effect was observed in subjects with a fasting WBG greater than 6.1 mM (or PG ≥ 7.0 mM).

Comparison of Anthropometric Parameters Among Various Glycemic Groups

Tables 2 and 3 show the comparison among normal controls, IFG-normal subjects, IFG-IGT subjects, and IFG-OGTT+ subjects, and new DM subjects (WBG ≥ 6.1 mM or PG ≥ 7.0 mM, but not on DM drugs). Mean fasting PG values in IFG-OGTT+, IFG-IGT, and IFG normal subjects were similar, but were significantly higher than that of normal controls. New DM patients had a significantly higher mean fasting PG than IFG-normal and IFG-IGT subjects. In men, the IFG-OGTT+ group had significantly higher values of weight, BMI, % fat, waist circumference, W/H ratio, and tricept and subscapular skinfold thickness than normal controls and higher values of BMI, waist circumference, W/H ratio, and subscapular skinfold thickness than the IFG-normal group. New DM men, IFG-OGTT+ men, and IFG-IGT men were also significantly shorter than IFG-normal men. In women, the IFG-OGTT+ group had significantly higher body weight, BMI, waist circumference, W/H ratio, and subscapular skinfold thickness than both the normal control group and the IFG-normal group. Greater % fat was observed in IFG-OGTT+ women compared to normal women. IFG-OGTT+ women were significantly shorter than their IFG-normal counterparts.

Effect of Age on the Risk of Undiagnosed DM

As shown in Tables 2 and 3, new DM, IFG-OGTT+, and IFG-IGT men were significantly older than IFG-normal men. New DM and IFG-OGTT+ women were also older than IFG-normal women. Since age was positively associated with W/H ratio (r=0.11 in men and r=0.36 in women), but negatively associated with BMI (r=-0.17 in men and r=-0.16 in women) and subscapular skinfold (r=-0.10 in men and r=-0.19 in women), we examined the age effect using multiple logistic regression analysis (Table 4). In men, age was independent of anthropometric variables in predicting DM or DM/IGT among IFG

Table 2. Comparison of Age, Fasting PG/WBG and Anthropometric Characterisitics by Fasting PG/WBG Range and Glucose Intolerance Status in Male Subjects without Past History of DM

	Male				
	PG < 6.1 mM WBG < 5.6 mM		6.1 ≤ PG < 7.0 mM 5.6 ≤ WBG < 6.1 mM		PG >= 7.0 mM WBG>= 6.1 mM
	Normal	IFG-normal	IFG-IGT	IFG-OGTT+	New DM
Subjects (n)	275	38	68	46	72
Age (years)	55.3 ± 12.4	50.8 ± 14.0[a]	56.4 ± 12.1[b]	60.2 ± 10.1[a,b]	59.0 ± 11.0[b]
Fasting PG (mM)	4.8 ± 0.4	5.7 ± 0.2	5.7 ± 0.2	5.8 ± 0.2[a,d]	8.1 ± 2.4[a,b,c]
Body Weight (kg)	64.4 ± 9.8	67.6 ± 8.8	68.5 ± 9.7	69.9 ± 10.9[a]	69.0 ± 10.3
Body Height (cm)	165.4 ± 5.8	167.3 ± 5.9	165.2 ± 5.3[b]	163.6 ± 5.4[b]	164.8 ± 5.3[b]
BMI (kg/m^2)	23.8 ± 3.3	24.6 ± 3.1	24.8 ± 3.0	26.0 ± 3.3[a,b,c]	25.3 ± 3.1[a]
Fat % (%)	21.6 ± 6.1	24.6 ± 11.1[a]	23.5 ± 6.1	24.5 ± 5.7[a]	24.2 ± 6.6[a]
Waist (cm)	84.3 ± 9.3	85.3 ± 9.6	88.1 ± 7.1[a]	92.2 ± 8.9[a,b,c]	89.5 ± 8.3[a,b]
W/H ratio	0.88 ± 0.06	0.88 ± 0.08	0.91 ± 0.06[a,b]	0.93 ± 0.06[a,b]	0.92 ± .05[a,b]
Tricept skinfold(mm)	11.2 ± 4.8	11.9 ± 4.8	12.0 ± 4.7	13.5 ± 5.6[a]	12.1 ± 4.7
Subscapular skinfold(mm)	16.4 ± 6.1	17.0 ± 6.5	18.1 ± 6.0	21.4 ± 5.9[a,b,c,d]	18.6 ± 5.9

Data are expressed as mean ± SD.
[a] $p < 0.05$ vs. subjects with fasting PG < 6.1 mM (WBG < 5.6 mM).
[b] $p < 0.05$ vs. IFG normal subjects with fasting PG between 6.1 and 7.0 mM (WBG between 5.6 and 6.1 mM).
[c] $p < 0.05$ vs. IGT subjects with fasting PG between 6.1 and 7.0 mM (WBG between 5.6 and 6.1 mM).
[d] $p < 0.05$ vs. DM subjects with fasting PG >= 7. 0 mM (WBG ≥ 6.1 mM).

Table 3. Comparison of Age, Fasting WBG and Anthropometric Characteristics by Fasting WBG Range and Glucose Intolerance Status in Female Subjects without Past History of DM

	Male				
	PG < 6.1 mM WBG < 5.6 mM		6.1 ≤ PG < 7.0 mM 5.6 ≤ WBG < 6.1 mM		PG >= 7.0 mM WBG>= 6.1 mM
	Normal	IFG-normal	IFG-IGT	IFG-OGTT+	New DM
Subjects (n)	274	21	69	64	94
Age (years)	56.6 ± 12.2	52.7 ± 14.4	56.5 ± 12.7	59.2 ± 10.9[b]	58.8 ± 11.5[b]
Fasting PG (mM)	4.7 ± 0.4	5.7 ± 0.2[a]	5.7 ± 0.2[a]	5.8 ± 0.2[a,d]	8.3 ± 2.4[a,b,c]
Body Weight (kg)	57.0 ± 9.0	57.7 ± 10.3	61.5 ± 10.2[a,b]	61.8 ± 9.9[a,b]	62.7 ± 9.5[a,b]
Body Height (cm)	152.8 ± 5.3[b]	155.9 ± 6.7	153.2 ± 6.3[b]	151.5 ± 5.1[b]	152.3 ± 5.2[b]
BMI (kg/m^2)	24.4 ± 3.7	23.7 ± 3.3	26.2 ± 3.7[a,b]	27.0 ± 4.4[a,b]	27.0 ± 3.7[a,b]
Fat % (%)	30.7 ± 6.5	31.5 ± 4.9	32.3 ± 6.7	34.0 ± 7.2[a]	34.0 ± 6.3[a]
Waist (cm)	78.2 ± 8.9	77.7 ± 6.9	83.5 ± 8.4[a,b]	85.4 ± 8.5[a,b]	85.8 ± 8.5[a,b]
W/H ratio	0.81 ± 0.07	0.81 ± 0.05	0.84 ± 0.05[a,b]	0.86 ± 0.06[a,b]	0.87 ± 0.08[a,b,c]
Tricept skinfold(mm)	19.4 ± 6.4	19.5 ± 6.3	21.2 ± 6.4	20.9 ± 6.6	20.6 ± 6.3
Subscapular skinfold(mm)	18.4 ± 6.1	19.2 ± 7.0	22.0 ± 7.5[a,b]	22.1 ± 6.4[a,b]	22.2 ± 7.6[a,b]

Data are expressed as mean ± SD.
[a] $p < 0.05$ vs. subjects with fasting PG < 6.1 mM (WBG < 5.6 mM).
[b] $p < 0.05$ vs. IFG normal subjects with fasting PG between 6.1 and 7.0 mM (WBG between 5.6 and 6.1 mM).
[c] $p < 0.05$ vs. IGT subjects with fasting PG between 6.1 and 7.0 mM (WBG between 5.6 and 6.1 mM).
[d] $p < 0.05$ vs. DM subjects with fasting PG >= 7. 0 mM (WBG ≥ 6.1 mM).

Table 4. Multiple Logistic Regression of the Effect of Age, Height, and Obesity Indices on DM Status

Variables[1]		Standardized			Standardized		
	SD[2]	Beta[3]	OR[4]	p-value	Beta	OR	p-value
On DM status		Women			Men		
Age	12.4	0.274	1.32	0.162	0.549	1.73	0.012
BMI	3.6	0.327	1.39	0.040	0.651	1.92	0.005
Height	8.4	-0.386	0.68	0.148	-0.496	0.61	0.107
Age	12.4	0.154	1.17	0.419	0.423	1.53	0.052
Waist	9.0	0.391	1.48	0.034	0.798	2.22	0.001
Height	8.4	-0.476	0.62	0.074	-0.671	0.51	0.037
Age	12.4	0.098	1.10	0.619	0.391	1.48	0.063
W/H	0.07	0.296	1.35	0.196	0.453	1.57	0.039
Height	8.4	-0.437	0.65	0.100	-0.432	0.65	0.156
Age	12.4	0.373	1.45	0.127	0.569	1.77	0.028
Subscapular skinfold	6.9	-0.011	0.99	0.961	0.597	1.82	0.015
Height	8.4	-0.612	0.54	0.096	-0.577	0.56	0.148
On DM/IGT status							
Age	12.4	0.365	1.44	0.158	0.520	1.68	0.017
BMI	3.6	0.773	2.17	0.004	0.385	1.47	0.107
Height	8.4	-0.564	0.57	0.157	-0.496	0.61	0.130
Age	12.4	0.118	1.13	0.647	0.432	1.54	0.046
Waist	9.0	0.970	2.64	0.002	0.617	1.85	0.006
Height	8.4	-0.782	0.46	0.050	-0.602	0.55	0.078
Age	12.4	0.018	1.02	0.947	0.393	1.48	0.068
W/H	0.07	0.707	2.03	0.046	0.612	1.84	0.011
Height	8.4	-0.655	0.52	0.092	-0.438	0.65	0.193
Age	12.4	0.627	1.87	0.046	0.247	1.28	0.363
Subscapular skinfold	6.9	0.477	1.61	0.173	0.549	1.73	0.064
Height	8.4	-0.759	0.47	0.133	-1.175	0.31	0.012

1 Age in years, BMI in Kg/M2, height in M, waist circumference in cm, and subcapular skinfold in cm.
2 Standard deviation of the corresponding variables.
3 Regression coefficients.
4 Odds ratio.

subjects. In women, however, age was not independently significant.

Multiple Logistic Regression on Relations between DM/IGT Status and Obesity Indices, Height, and Age (Table 4)

When age, height, and one of the obesity indices were included in the multiple regression model, waist circumference appeared to be the best indicator of DM status or DM/IGT status. One standard deviation increase (9.0 cm) in waist circumference corresponded to a 2.22 fold DM risk in men and 1.48 fold DM risk in women. The same change corresponded to a 1.85 DM/IGT risk in men and 2.64 DM/IGT risk in women. In this model of waist circumference, one standard deviation increase in height (8.4 cm) corresponded to roughly a 50% reduction in both DM risk and DM/IGT risk.

Discussion

Patients with undiagnosed and untreated diabetes will develop DM complications. Early diagnosis can lead to lifestyle modification and prompt control of hyperglycemia and in turn prevent ravages brought by DM (14). According to the results of OGTT, we found that 30% of the IFG men and 42% of IFG

women were diabetic. In addition, 75% of IFG men and 86% of IFG women were either glucose intolerant or diabetic. It is helpful to be able to identify OGTT positive individuals in the IFG range. We found in this study that central obesity, female sex, age, and short stature are potential indicators of undiagnosed DM and glucose intolerance.

The influence of gender on the prevalence of diabetes varies between populations (15). Lee et al. (16) reported that among American Indians, diabetes was more prevalent in women than in men. Harris concluded that gender did not appear to be an important determinant of Type 2 DM, since the ratio of the age-standardized rate of total diabetes in women compared with men was 1.2 for black and 1.3 for white Americans (17). Several population studies in India showed that diabetes is more frequent in men than in women (18). In Taiwan, previous reports (19-21) demonstrated a higher prevalence of diabetes in women than in men. We found in the present study that women were preponderant over men not only in terms of the prevalence of DM but also in rates of DM and IGT as a whole in all fasting PG/WBG ranges studied. Therefore, female sex was a strong indicator of DM for subjects with impaired fasting glucose. We propose two explanations for this gender difference. First, we found that women with undiagnosed DM were more obese compared to men with undiagnosed DM, suggesting that obesity may explain the risk associated with female sex (4). Second, it is possible that the positive response to the oral glucose challenge may result from a fixed glucose load for all subjects, which is relatively large for women.

Obesity is a well-recognized risk factor for the development of non-insulin-dependent DM (22). Several studies have also shown that central fat distribution is particularly associated with an increased prevalence of DM (23-24). In the present study, undiagnosed DM men and women were more obese, particularly more centrally obese, than IFG-normal controls. Our logistic regression data suggest that values of central obesity indices, such as waist circumference or waist-hip ratio, can be used to identify undiagnosed DM in IFG subjects. Other significant obesity indices in univariated analyses, such as BMI, body weight in women and subscapular skinfold in men, were not associated with undiagnosed DM to the extent of waist circumference.

The association between height and glucose intolerance remains controversial in the literature. Williams et al. (25) first reported 7 IGT subjects (6 men and 1 woman) that were significantly shorter than controls, and they speculated about the possible influence of early β cell dysfunction. Later, in a prospective population survey, the same group of researchers reported that in both men and women height had a significant independent negative association with plasma glucose at 120 minutes after administration of oral glucose (26-27). Other studies could not confirm the association in European men (28-29). Our data demonstrated that shorter stature was significantly associated with the DM status and/or IGT status in IFG men and women.

In conclusion, we found a moderate undiagnosed DM rate and a high IGT/DM rate in IFG Taiwanese, using fasting PG/WBG of 6.1 mM/6.7 mM as the criteria for IFG and using OGTT positive to define diabetes. This high rate of IGT/DM in Taiwan warrants further studies. Central obesity, female sex, male's age, and short stature were indicators of undiagnosed DM in these IFG subjects. We propose that the high rate of glucose intolerance in women with fasting PG/WBG between 6.1 (5.6) and 6.7 (6.1) mM may in part be explained by their obesity status and short stature.

Acknowledgments

The survey was supported by grants (DOH-83-FS-41,DOH-84-FS-11, DOH-85-FS-11,DOH-86-FS-11, and DOH-83-TD-015, DOH-84-TD-006) from Department of Health, Republic of China.

References

1. Amos A.F., McCarty D.J. and Zimmet O. The rising global burden of diabetes andits complications: estimates and projections to the year 2010. *Diabet. Med.* 14: 5 :SI-85, 1997.
2. Albert K.G.M.M. and Zimmer P.Z. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: Diagnosis and classification of diabetes mellitus. Provisional Report of a WHO Consultation. *Diabet. Med.* 15: 539-553, 1998.
3. Pan W.H., Yeh W.T., Hwu C.M. and Ho L.T. Prevalence and Awareness of Diabetes and Mean Fasting Glucose Values in Taiwan: Results from the Nutrition and Health Survey in Taiwan (NAHSIT), 1993-1996. In Report of Nutrition and Health Surveillance in Taiwan . Department of Health,The Executive Yuan,Taipei, p279-290, 1998.
4. Wang S.L., Pan W.H., Hwu C.M., et al. Incidence of NIDDM and the effects of gender, obesity and hyperinsulinaemia in Taiwan. *Diabetologia* 40: 1431-1438, 1997.
5. Department of Statistics, Ministry of the Interior. National survey of general life situation in Taiwan area, Republic of China. Taipei: *Forever-New*, 1997, 1998, 1999.
6. Harris M.I. Undiagnosed NIDDM. clinical and public health issues. *Diabete. Care.* 16: 642-652, 1993.
7. Eschwege E., Richard J.L., Thibult N., et al. Coronary heart disease mortality in relation with diabetes, blood glucose, and plasma insulin levels, the Paris Prospective Study ten years later. *Hor. Metab. Res.* 15(suppl): 41-46, 1985.
8. Jarrett R.J. and Shipley M.J. Type II (non-insulin-dependent) diabetes mellitus and cardiovascular disease - putative association via common antecedents. further evidence from the Whitehall Study. *Diabetologia* 31: 737-740, 1988.
9. Pan W.H., Kao M.D., Tzeng M.S., Yen L.L., et al. Nutrition and health survey in Taiwan (NAHSIT) 1993-1996: design, contents, and operations. *Nutritional Sciences Journal* 24:1-8, 1999.
10. Chang H.Y., Pan W.H., Yeh W.T. and Tsai K.S. Hyperuricemia in Taiwan: results from the nutritional and health survey in Taiwan

(NAHSIT: 1993-1996). *J. Rheumotology* 1999 (In press).
11. Yeh C.J., Pan W.H., Bai C.H., et al. Curvilinear relations between age and hemostatic parameters in Chinese. *Thrombosis. Haemostasis.* 72: 239-243, 1994.
12. Ho L.T., Chang Z.Y., Wang J.T., Li, S.H., Liu, Y.F., Chen, Y.D. and Reaven, G.M. Insulin insensitivity in offspring of parents with type 2 diabetes mellitus. *Diabetic. Med.* 7: 31-34, 1990
13. Nakadomo F., Tanaka K., Hazzama T. and Maeda K. Validation of body composition assessed by bioelectrical impedance analysis. *Jpn. J. Appl. Physiol.* 20: 321-330, 1990.
14. Harris MI, Eastman RC. Early detection of undiagnosed non-insulin-dependent diabetes mellitus. *JAMA* 276: 1261-1262, 1996.
15. Dowse G.K. and Zimmet P.Z. The prevalence of non-insulin-dependent diabetes mellitus. In: Alberti KGMM, Mazze R, eds. Frontiers of diabetes research: current trends in non-insulin-dependent diabetes mellitus. *Amsterdam: Elservier Science*, p. 37-59, 1989.
16. Lee E.T., Howard B.V., Savage P.J., et al. Diabetes and impaired glucose tolerance in three American Indian populations aged 45-74 years. *Diabet. Care* 18: 599-610, 1995.
17. Harris M.I. Non-insulin-dependent diabetes mellitus in black and white Americans. *Diabetes Metab Rev* 6: 71-90, 1990.
18. Ramaiya K.L., Kodali V.R.R. and Alberti K.G.M.M. Epidemiology of diabetes in Asians of the Indian Subcontinent. *Diabet. Metab. Rev.* 6: 125-146, 1990
19. Chang C.J., Shin S.J., Lee W.L., Horng N.C., Lee Y.J., and Liu H. W. Influence of central obesity and obesity level on the prevalence of NIDDM and impaired glucose tolerance. *Kaohsiung. J. Med. Sci.* 8: 647-655, 1992.
20. Chou P., Chen H.H. and Hsiao K.J. Community-based epidemiological study on diabetes in Pu-Li, Taiwan. *Diabet. Care* 15: 81-89, 1992.
21. Tai T.Y., Yang C.L., Chang C.J., et al. Epidemiology of diabetes mellitus among adults in Taiwan, R.O.C. *J. Med. Assoc. Thai.* 70 (Supp 2): 42-48, 1987.
22. Pederson O. The impact of obesity on the pathogenesis of non-insulin-dependent diabetes mellitus: a review of current hypotheses. *Diabet. Metab. Rev.* 5: 495-509, 1989.
23. Stern M.P. and Haffner S.M. Body fat distribution and hyperinsulinemia as risk factors for diabetes and cardiovascular disease. *Arteriosclerosis* 6: 123-130, 1986.
24. Bjrntorp P. The associations between obesity, adipose tissue distribution and disease. *Acta. Med. Scand.* 723 (Supp): 121-134, 1988.
25. Williams D.R.R., Byrne C., Clark P.M.S., et al. Raised proinsulin concentration as early indicator of β cell dysfunction. *BMJ* 303: 95-96, 1991.
26. Brown D.C., Byrne C.D., Clark P.M., Cox, B.D., Day, N.E., Hales, C.N., Shackleton, J.R., Wang, T.W. and Williams, D.R. Height and glucose tolerance in adult subjects. *Diabetologia* 34: 531-533, 1991.
27. Williams D.R., Wareham N.J. and Brown D.C., et al. Undiagnosed glucose intolerance in the community: the Isle of Ely Diabetes Project. *Diabetic Med.* 12: 30-35, 1995.
28. McKeigue P.M. Impaired glucose tolerance and height. *BMJ* 303: 365, 1991.
29. Ohlson L.-O., Larsson B., Erisson H., Svrdsudd K., Welin L. and Tibblin G. Diabetes mellitus in Swedish middle-aged men: the study of men born in 1913 and 1923. *Diabetologia* 30: 386-393, 1987.