Cardiovascular Risk Profile in Individuals With Borderline Glycemia

The effect of the 1997 American Diabetes Association diagnostic criteria and the 1998 World Health Organization Provisional Report

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OBJECTIVE — In 1997, the American Diabetes Association (ADA) recommended a new diagnostic category, impaired fasting glucose (IFG), to describe individuals with borderline glucose tolerance. On the other hand, the World Health Organization (WHO) suggested retaining the category of impaired glucose tolerance (IGT). We studied the prevalence of IFG and IGT in a multiethnic society and compared the cardiovascular risk profiles of subjects with IFG, IGT, or both IFG and IGT.

RESEARCH DESIGN AND METHODS — A total of 3,568 subjects were examined from the 1992 National Health Survey of Singapore, which involved a combination of disproportionately stratified sampling and systematic sampling. Anthropometric, blood pressure, insulin, lipid profile, and uric acid measurements were taken, and a standard 75-g oral glucose tolerance test was performed after a 10-h overnight fast.

RESULTS — The prevalence rates of IFG only, IGT only, and both IFT and IGT were 3.45, 10.2, and 3.4%, respectively. The degree of agreement (κ) between the two diagnostic criteria (the ADA IFG and the WHO IGT) was only 0.25. A fasting glucose level of 5.5 mmol/l was the optimal cutoff for predicting a 2-h postload glucose level of $\geq$7.8 mmol/l. The following cardiovascular risk factors were higher in subjects with both IFG and IGT compared with those with either IFG or IGT alone: systolic blood pressure (131 ± 20 vs. 125 ± 21 and 125 ± 19 mmHg, respectively; $P < 0.05$ and $P < 0.001$, respectively); diastolic blood pressure (77 ± 12 vs. 73 ± 12 and 74 ± 12 mmHg, respectively; $P < 0.05$); BMI (26.2 ± 4.2 vs. 24.4 ± 4.0 and 24.6 ± 4.4 kg/m^2, respectively; $P < 0.01$ and $P < 0.001$, respectively); waist circumference (84.1 ± 10.3 vs. 79.3 ± 10.7 and 79.3 ± 10.6 cm, respectively; $P < 0.001$); waist-to-hip ratio (0.84 ± 0.08 vs. 0.82 ± 0.09 and 0.81 ± 0.08, respectively; $P < 0.05$ and $P < 0.001$, respectively); fasting insulin (12.1 ± 9.7 vs. 9.2 ± 5.3 and 9.9 ± 7.7 mU/l; $P < 0.01$); insulin resistance (by homeostasis model assessment [HOMA]) (3.41 ± 2.77 vs. 2.58 ± 1.50 and 2.43 ± 1.83, respectively; $P < 0.01$ and $P < 0.001$, respectively); total cholesterol (5.81 ± 1.1 vs. 5.51 ± 1.1 and 5.53 ± 1.1 mmol/l, respectively; $P < 0.05$) and apolipoprotein(B) [apo(B)] (1.5 ± 0.38 vs. 1.40 ± 0.34 and 1.39 ± 0.35 mmol/l, respectively; $P < 0.01$). The pattern of difference remained significant only for fasting insulin, insulin resistance (HOMA), and apo(B) (borderline) after adjustment for age, sex, and ethnic differences.

CONCLUSIONS — Obvious discordance was evident in the classification of glycemic status when applying the criteria proposed by the ADA (IFG) or WHO (IGT) in a multiethnic society like Singapore. However, subjects with either IFG or IGT had similar cardiovascular risk profiles. Therefore, both criteria identified individuals at high risk for cardiovascular disease. Individuals with both IFG and IGT had a greater incidence of the cardiovascular dysmetabolic syndrome.

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In 1997, the Expert Committee on the Classification and Diagnosis of Diabetes Mellitus of the American Diabetes Association (ADA) recommended a new set of diagnostic criteria for diabetes (1). One major change in the diagnostic criteria was the creation of a new category of borderline glucose intolerance known as impaired fasting glucose (IFG), which ADA defined as a fasting plasma glucose (FPG) level between 6.1 and 6.9 mmol/l. The same committee also recommended the use of FPG versus an oral glucose tolerance test (OGTT). On the other hand, the 1998 Provisional Report of a World Health Organization (WHO) consultation suggested retaining the category of impaired glucose tolerance (IGT), which WHO redefined as a fasting glucose level <7.0 mmol/l in addition to a 2-h postload glucose (2-h PG) level between 7.8 and 11.1 mmol/l (2). Individuals conceivably may be classified as having either IFG or IGT or both IFG and IGT (denoted as groups 1, 2, and 3, respectively, in the present study) after an OGTT.

We know that subjects with IGT are at risk for diabetes and cardiovascular diseases (3). Recent data suggest that individuals with fasting glucose levels in the range defined by IFG are also predisposed to cardiovascular events (4). Therefore, two pertinent questions arise. First, do IFG or IGT identify the same individuals in a given population? Second, do subjects with IFG or IGT or both IFG and IGT have similar cardiovascular risk profiles? We sought to answer these questions by studying individuals with IFG or IGT in the 1992 Singapore National Health Survey.

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Abbreviations: ADA, American Diabetes Association; ANCOVA, analysis of covariance; apo, apolipoprotein; dBP, diastolic blood pressure; FPG, fasting plasma glucose; HOMA, homeostasis model assessment; IFG, impaired fasting glucose; IGT, impaired glucose tolerance; IR, insulin resistance; NGT, normal glucose tolerance; OGTT, oral glucose tolerance test; ROC, receiver operator characteristics; sBP, systolic blood pressure; TC, total cholesterol; TG, triglyceride; 2-h PG, 2-h postload glucose; WHO, World Health Organization; WHR, waist-to-hip ratio.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Table 1—*Sex, age, and ethnic differences between subjects with IFG, IGT, and both IFG and IGT*

	IFG (group 1)	IGT (group 2)	Both (group 3)
Sex			
Male	75 (61.5)	158 (45.4)	61 (50.4)*
Female	47 (38.5)	190 (54.6)	60 (49.6)*
Age (years)			
18–39	47 (38.5)	158 (45.4)	34 (28.1)†
40–54	44 (36.1)	122 (35.1)	46 (38.0)†
55–69	31 (25.4)	68 (19.5)	41 (33.9)†
Ethnic group			
Chinese	72 (59.0)	254 (73.0)	83 (68.6)‡
Malay	30 (24.6)	55 (15.8)	17 (14.1)‡
Asian Indian	20 (16.4)	39 (11.2)	21 (17.4)‡

Data are *n* (%). *P* values for the χ^2 test are as follows: **P* = 0.009; †*P* = 0.005; and ‡*P* = 0.027.

RESEARCH DESIGN AND METHODS

Subjects and methods

The study methodology and population characteristics have been described elsewhere (5). Briefly, 3,568 individuals aged 18–69 years were selected by disproportionate stratified sampling followed by systematic sampling. Minority races (Asian Indians and Malays) were oversampled to ensure an adequate sample size for statistical analysis. Blood pressure and anthropometric data (weight, height, waist circumference, and waist-to-hip ratio [WHR]) were measured for all individuals. In addition, blood lipids (total cholesterol [TC], triglyceride [TG], and HDL cholesterol), glucose, and insulin were assayed after a 10-h fast. All subjects who were not taking oral hypoglycemic agents or insulin underwent an OGTT. Plasma glucose and serum insulin were measured again 2 h after the OGTT.

Glucose measurements were carried out with the glucose oxidase method using the Vitros 700 Chemistry Analyzer (Rochester, NY). Insulin was assayed with a microparticle enzyme immunoassay using the Abbot AxSYM insulin assay (Chicago). Cholesterol and TG were measured with enzymatic methods using Eastman-Kodak Ektachem chemistry slides (Rochester, NY), which were then read on a Vitros 700 Chemistry Analyzer. HDL cholesterol was measured after precipitation with dextran sulfate and magnesium chloride. LDL cholesterol was calculated using Friedewald's formula. Apolipoprotein(A) [apo(A)] and apo(B) were measured by rate nephelometry using the Array® Protein System (Beckman Instruments, Galway, Ireland), respectively. Insulin resistance (IR) was calculated using homeostasis model assessment (HOMA) (6).

Subjects were defined as having IFG alone (group 1) if their FPG level was between 6.1 and 6.9 mmol/l and if their 2-h PG level was <7.8 mmol/l. Individuals were diagnosed with IGT alone (group 2) if their FPG level was ≤6.0 mmol/l in addition to a 2-h PG level between 7.8 and 11.1 mmol/l. A final group of subjects (group 3) was diagnosed as having both IFG and IGT if their FPG level was between 6.1 and 6.9 mmol/l in addition to a 2-h PG level between 7.8 and 11.1 mmol/l. Subjects with diabetes were excluded from the analysis.

Statistical analysis

SPSS for Windows version 9.0 (Chicago) was used for statistical analyses. Agreement between IFG and IGT was examined with the κ test. The κ statistic was derived from the population consisting of the following groups: normal glucose tolerance (NGT) (*n* = 2,602), IFG, IGT, or both IFG and IGT. Subjects with diabetes (according to either ADA or WHO criteria) were excluded. A value of 1 indicates perfect agreement, whereas a value of 0 indicates that the agreement is no better than chance. A value <0.40 may represent poor agreement (7). Receiver operator characteristics (ROC) curve analysis was used to calculate the fasting glucose level that best predicts a 2-h PG of ≥7.8 mmol/l (8). Comparison of proportions for sex, age, and ethnicity between the three diagnostic groups was carried out using the χ^2 test for independence. Variables that were not normal in distribution were log transformed to reduce skewness. These variables were systolic (sBP) and diastolic (dBP) blood pressure, BMI, waist circumference, TC, HDL cholesterol, TG, apo(A), fasting insulin, and IR. The transformed figures were subsequently back transformed for presentation. When analyzing the TG levels, subjects with fasting TG levels >10.0 mmol/l were excluded because these subjects most probably had chylomicronemia, and their fasting TG levels would have severely skewed the TG levels in the population. One-way analysis of variance was used to compare unadjusted variables between the three groups. Analysis of covariance (ANCOVA) adjusted for age, sex, and ethnicity (as covariates) was used for multivariate analysis of cardiovascular risk factors between the diagnostic groups. Interactions between the three diagnostic groups and age or sex either were not significant or were marginally significant. However, significant interactions were evident between the three diagnostic groups and ethnicity regarding the measurements of obesity (i.e., BMI, waist circumference, and WHR) and apo(A) levels. ANCOVA controlled for age and sex was performed separately for each ethnic group.

RESULTS

— A total of 122 subjects (3.45%) had IFG alone (group 1), 348 subjects (10.2%) had IGT alone (group 2), and 121 subjects (3.4%) satisfied the criteria for both IFG and IGT (group 3). A total of 2,602 subjects (73.2%) were considered NGT (i.e., not having diabetes, IFG, or IGT). A total of 74.2% of the subjects with IGT did not have IFG [i.e., 348/(121 + 348)], whereas 50.2% of the subjects with IFG did not have IGT [i.e., 122/(121 + 122)]. The degree of agreement between IFG and IGT (κ) was only 0.25. Using ROC curve analysis, the fasting glucose level that best predicted a 2-h PG of ≥7.8 mmol/l was 5.5 mmol/l (sensitivity of 70.2%, specificity of 68.2%).

The demographic features are shown in Table 1. The demographic distribution in the three diagnostic groups was different. Group 1 had proportionately more male subjects than group 2. In addition, proportionately more Chinese subjects were in group 2 (73.0%) than in group 1 (59.0%), and more Asian Indians were in group 3 (17.4%) than in group 1 (16.4%) and group 2 (11.2%).

Table 2 shows the percentage of subjects in each group with cardiovascular risk factors above levels that are widely recognized as undesirable. Group 3 had a higher prevalence of overweight subjects (i.e., BMI ≥27 kg/m^2) than group 1 and group 2. A trend suggested that individuals in group 3 had a

Table 2—*Percentage of subjects in each group with undesirable levels of cardiovascular risk factors*

	Subjects				
	IFG (group 1)	IGT (group 2)	Both (group 3)	*P**	NGT
n	122	348	121	—	2,602
Hypertension (sBP ≥140 mmHg or dBP ≥90 mmHg)	25.6	28.2	37.2	0.099	8.6
BMI ≥27 kg/m^2	22.1	25.9	37.2	0.019	9.6
WHR (15) (male >1.0; female >0.85)	1.6	4.3	5.79	0.245	1.2
TC ≥5.2 mmol/l	61.5	64.1	73.6	0.097	43.4
HDL <0.9 mmol/l	16.4	8.9	5.8	0.014	11.6
LDL ≥3.3 mmol/l	62.3	60.2	70.4	0.145	48.2
TG ≥1.7 mmol/l	36.9	38.5	45.5	0.319	16.7

Data are %. The corresponding values for the cohort with NGT are included for reference. **P* values for the χ^2 test.

higher prevalence of hypertension (i.e., sBP ≥140 mmHg or dBP ≥90 mmHg) and hypercholesterolemia (i.e., TC ≥5.2 mmol/l) than subjects in group 1 and group 2. Subjects in group 1 had a higher prevalence of low HDL cholesterol compared with subjects in group 2 and group 3. The proportions of individuals receiving blood pressure–lowering therapy in groups 1, 2, and 3 were 10.6, 10.9, and 11.6%, respectively. The proportion of subjects receiving lipid-lowering therapy was not known.

The detailed cardiovascular risk profiles of subjects with IFG, IGT, or both IFG and IGT are shown in Table 3 for comparisons between groups. The cardiovascular risk factors in subjects with IFG (group 1) did not differ significantly from those in subjects with IGT (group 2). In contrast, the following cardiovascular risk factors were more pronounced in group 3 compared with group 1 and group 2: age, sBP, dBP, BMI, waist circumference, WHR, fasting insulin, IR, apo(B), and TC. LDL cholesterol levels were also higher in group 3 than in group 2. Although a trend suggested that some risk factors were also more prominent among individuals in group 3 (e.g., apo(A), HDL cholesterol, and TG levels), the difference failed to reach statistical significance.

The cardiovascular risk profiles of these three groups were reexamined after adjusting for age, sex, and ethnicity with ANCOVA (Table 4). When compared with subjects in group 1 and group 2, subjects in group 3 were still significantly more insulin resistant (i.e., had higher fasting insulin levels [$P < 0.01$] and IR [HOMA] values [$P < 0.05$ and $P < 0.001$, respectively]). Subjects in group 3 also had higher apo(B) levels than subjects in group 1 ($P < 0.05$).

Because of significant interactions between ethnicity and the three diagnostic groups, the results of the measurements of obesity (i.e., BMI, waist circumference, and WHR) and apo(A) levels were presented separately for the three major ethnic groups in Table 5. For the Chinese subjects, subjects in group 3 had higher measurement of overall obesity (BMI) and central obesity (waist circumference) than subjects in group 1 and group 2. For the Malay subjects, the waist circumference of subjects in group 3 was higher than that in subjects in group 1 and group 2. In contrast, the Asian Indians in group 3 did not have greater measurements of obesity compared with those in group 1 and group 2. Apo(A) levels were also lower in group 3 compared with group 1 for the Chinese subjects.

CONCLUSIONS — To our knowledge, this is the first article to examine the effect of the 1997 ADA and 1998 WHO diagnostic criteria (which recommend the cutoff of FPG for IGT to be reduced to 7.0 mmol/l)

Table 3—*Unadjusted cardiovascular risk profile of subjects with IFG, IGT, or both IFG and IGT*

				P			
	IFG (group 1)	IGT (group 2)	Both (group 3)	Group 1 vs. group 2	Group 1 vs. group 3	Group 2 vs. group 3	NGT
n	122	348	121	—	—	—	2,602
Age (years)	44.4 ± 13.0	42.5 ± 13.0	47.9 ± 11.3	NS	<0.05	<0.001	34.7 ± 11.6
sBP (mmHg)	125 ± 21	125 ± 19	131 ± 20	NS	<0.05	<0.001	114 ± 15
dBP (mmHg)	73 ± 12	74 ± 12	77 ± 12	NS	<0.05	<0.05	66 ± 11
BMI (kg/m^2)	24.4 ± 4.0	24.6 ± 4.4	26.2 ± 4.2	NS	<0.01	<0.001	22.3 ± 3.8
Waist circumference (cm)	79.3 ± 10.7	79.3 ± 10.6	84.1 ± 10.3	NS	<0.001	<0.001	72.8 ± 10.1
WHR	0.82 ± 0.09	0.81 ± 0.08	0.84 ± 0.08	NS	<0.05	<0.001	0.77 ± 0.08
Fasting insulin (U/l)	9.2 ± 5.3	9.9 ± 7.7	12.1 ± 9.7	NS	<0.01	<0.01	6.8 ± 4.6
IR (HOMA)	2.58 ± 1.50	2.43 ± 1.83	3.41 ± 2.77	NS	<0.01	<0.001	1.61 ± 1.13
Apo(A) (mmol/l)	1.41 ± 0.28	1.41 ± 0.26	1.40 ± 0.24	NS	NS	NS	1.40 ± 0.24
Apo(B) (mmol/l)	1.40 ± 0.34	1.38 ± 0.35	1.50 ± 0.38	NS	<0.05	<0.01	1.22 ± 0.34
TC (mmol/l)	5.5 ± 1.1	5.5 ± 1.1	5.8 ± 1.1	NS	<0.05	<0.05	5.2 ± 1.0
HDL (mmol/l)	1.2 ± 0.33	1.2 ± 0.32	1.2 ± 0.27	NS	NS	NS	1.3 ± 0.3
LDL (mmol/l)	3.6 ± 0.91	3.6 ± 0.99	3.8 ± 1.07	NS	0.052	<0.05	3.3 ± 0.9
TG (mmol/l)	1.7 ± 1.14	1.7 ± 1.24	1.9 ± 1.29	NS	NS	NS	1.2 ± 1.2

Data are means ± SD. The corresponding values for the cohort with NGT are included for reference.

Table 4—*Cardiovascular risk profile of subjects with IFG, IGT, or both IFG and IGT adjusted by age, sex, and ethnic group*

	IFG (group 1)	IGT (group 2)	Both (group 3)	*P*		
				Group 1 vs. group 2	Group 1 vs. group 3	Group 2 vs. group 3
n	121	357	122	—	—	—
sBP (mmHg)	122 (119–125)	123 (121–125)	127 (123–130)	NS	<0.05	0.066
dBP (mmHg)	71 (69–73)	73 (72–75)	75 (73–77)	NS	<0.05	NS
Fasting insulin (U/l)	8.8 (7.9–9.8)	9.0 (8.3–9.6)	10.9 (9.8–12.2)	NS	<0.01	<0.01
IR (HOMA)	2.46 (2.2–2.8)	2.2 (2.0–2.4)	3.1 (2.7–3.4)	NS	<0.05	<0.001
Apo(B) (mmol/l)	1.41 (1.35–1.47)	1.44 (1.40–1.48)	1.53 (1.45–1.57)	NS	<0.05	0.051
TC (mmol/l)	5.4 (5.21–5.59)	5.5 (5.35–5.62)	5.6 (5.43–5.83)	NS	NS	NS
HDL (mmol/l)	1.1 (1.10–1.19)	1.1 (1.10–1.16)	1.1 (1.07–1.17)	NS	NS	NS
LDL (mmol/l)	3.6 (3.40–3.77)	3.7 (3.56–3.81)	3.8 (3.62–3.99)	NS	NS	NS
TG (mmol/l)	1.4 (1.28–1.56)	1.6 (1.38–1.58)	1.6 (1.46–1.80)	NS	NS	NS

Data are means (95% CIs).

on IFG and IGT in a population survey. Previous articles compared the ADA criteria with the 1985 WHO criteria when IGT was still defined as an FPG level <7.8 mmol/l in addition to a 2-h PG level between 7.8 and 11.1 mmol/l (9,10). In this article, we have shown that, in a multiethnic society like Singapore, considerable discordance existed in the diagnoses of IFG and IGT, with an agreement (κ) of only 0.25, and that the fasting glucose level that best predicted a 2-h PG of ≥7.8 mmol/l (i.e., IGT) was 5.5. mmol/l but not 6.1 mmol/l (the lowest cutoff for one to be considered IFG). Therefore, switching from one criterion to another (e.g., from WHO to ADA) not only would involve a change in the prevalence of borderline glucose anomalies but also would involve labeling a different group of individuals as having abnormal glucose metabolism. In addition, of all of the subjects who had a fasting glucose level within the IFG range, 19.9% had a 2-h PG level >11.1 mmol/l (i.e., diabetes) (data not shown). This suggested that, without an OGTT, we would have classified a sizable group of diabetic individuals (based on 2-h PG) as having IFG who are at risk for both micro- and macroangiopathy.

Because obvious discordance existed between IFG and IGT in our population, one important issue is whether these two groups of subjects (group 1 and group 2) carried a similar level of cardiovascular risk. Our data suggested that the cardiovascular risk profiles in subjects with either IFG or IGT were indistinguishable with and without adjustment for age, sex, and ethnicity (Table 3 and 4). Therefore, using either diagnostic criteria would identify individuals at a similar risk for cardiovascular diseases. Our finding differed from that of the Hoorn Study, which demonstrated that subjects with IGT (based on the 1985 WHO criteria) carried a slightly greater risk of cardiovascular diseases (higher TG and lower HDL cholesterol levels in the IGT group) (8). We believe that this was because, in the Hoorn Study, subjects with an FPG level between 7.0 and 7.8 mmol/l were included in the group with IGT. Hence, individuals with diabetes were inadvertently included

Table 5—*BMI, waist circumference, WHR, and apo(A) among the three ethnic groups with IFG, IGT, or both IFG and IGT adjusted by age and sex*

Subjects	IFG (group 1)	IGT (group 2)	Both (group 3)	*P*		
				Group 1 vs. group 2	Group 1 vs. group 3	Group 2 vs. group 3
Chinese						
BMI (kg/m^2)	23.5 (16.14–34.23)	23.6 (19.36–28.88)	25.3 (17.74–35.87)	NS	<0.05	<0.01
WHR	0.81 (0.68–0.94)	0.81 (0.75–0.89)	0.83 (0.71–0.95)	NS	NS	NS
Waist circumference (cm)	77.6 (59.3–100.9)	78.0 (67.3–89.5)	81.3 (63.4–104.2)	NS	<0.01	<0.01
Apo(A) (mmol/l)	1.46 (1.03–2.19)	1.40 (1.13–1.74)	1.36 (1.07–1.99)	NS	<0.05	NS
Malay						
BMI (kg/m^2)	25.1 (13.79–45.79)	24.7 (15.99–38.05)	27.7 (12.43–61.56)	NS	NS	<0.05
WHR	0.80 (0.58–1.02)	0.81 (0.66–0.96)	0.84 (0.56–1.12)	NS	NS	NS
Waist circumference (cm)	77.6 (50.4–119.7)	77.6 (56.8–106.7)	84.3 (47.9–151.4)	NS	<0.05	<0.05
Apo(A) (mmol/l)	1.33 (0.69–2.55)	1.38 (0.86–2.21)	1.44 (0.60–3.43)	NS	NS	NS
Asian Indian						
BMI (kg/m^2)	25.4 (12.08–53.2)	27.4 (15.87–47.16)	26.5 (15.87–55.41)	NS	NS	NS
WHR	0.82 (0.50–1.14)	0.87 (0.63–1.110	0.86 (0.54–1.18)	<0.05	NS	NS
Waist circumference (cm)	81.3 (43.9–150.7)	88.9 (71.0–139.6)	85.1 (46.1–158.5)	<0.05	NS	NS
Apo(A) (mmol/l)	1.30 (0.61–2.76)	1.23 (0.70–2.17)	1.33 (0.63–2.82)	NS	NS	NS

Data are means (95% CIs).

in the IGT group during analysis, thereby skewing the risk profile in these individuals toward greater cardiovascular risk. In our population, the number of subjects with IGT alone (group 2) was nearly threefold that of subjects with IFG alone (group 1), and this observation would have significant public health implications (i.e., if the OGTT had been omitted in our population survey, we would have missed a large group of individuals who had considerable cardiovascular risk but who could only be identified based on an abnormal 2-h PG).

Accumulating evidence suggests that individuals with nondiabetic-range hyperglycemia (involving both fasting glucose and 2-h PG) were already at risk for cardiovascular diseases (11,12). Our data in Table 2 show that the diagnoses of IFG, IGT, or both IFG and IGT indeed captured a group of subjects with adverse cardiovascular risk profiles. A considerable proportion of subjects in all of the groups were overweight, had hypertension, and had undesirable lipid profiles. These adverse factors may have contributed to the excess cardiovascular risk in subjects with borderline glycemia. In addition, a higher prevalence of obese individuals was evident, as was a trend toward a higher prevalence of hypertensive and hypercholesterolemic subjects among those who fulfilled the criteria for both IFG and IGT (i.e., the overlap group) compared with either diagnosis alone. This suggests that the diagnosis of this overlap group (group 3) had a special meaning in that these individuals had an even higher cardiovascular risk than those with either diagnosis alone. In a previous article from the same survey, Tan et al. (5) reported a higher prevalence of the cardiovascular dysmetabolic syndrome among Asian Indians compared with Malay and Chinese subjects (5). They suggested that this may have contributed to the higher incidence of cardiovascular disease among the Asian Indians. In the present study, we have shown that more Asian Indians were in group 3 compared with group 1 and group 2 (Table 1), and individuals in group 3 had a greater manifestation of the cardiovascular dysmetabolic syndrome. Therefore, these data would be consistent with the proposal that Asian Indians are prone to cardiovascular disease because of a higher prevalence of the cardiovascular dysmetabolic syndrome.

Our data in Table 3 further supported this notion. Among the individuals in group 3, many of the known cardiovascular risk factors were significantly more pronounced than in subjects in group 1 or group 2. Moreover, fasting insulin levels, IR (HOMA), and apo(B) remained significantly higher in group 3 compared with group 1 and group 2, even after adjusting for age, sex, and ethnicity (Table 4). Recent data from the Insulin Resistance Atherosclerosis Study suggested that IR per se was independently associated with atherosclerotic diseases (13). Anthropometric measurements of overall obesity (BMI) and abdominal obesity (waist circumference) were also higher in group 3 among the Chinese and Malay subjects after adjusting for age and sex (Table 5), which thereby suggests again a greater cardiovascular risk for these individuals. This was not observed among the Asian Indian subjects, partly because of the small number of Asian Indian subjects in the current survey. Hence, individuals with both IFG and IGT were at greater risk for cardiovascular diseases than those with either diagnosis alone, and this difference in risk was not explained by differences in age, sex, or ethnicity. Large-scale prospective studies have demonstrated that long-term lifestyle intervention is invaluable in reducing the mortality of individuals with IGT (14). Special attention should be given to this group of individuals who could be identified with a standard OGTT, and an intensive lifestyle modification program should be considered.

In summary, the IFG proposed by ADA in 1997 and the IGT recommended by WHO in 1998 showed significant discordance in a multiethnic society. However, individuals with either IFG or IGT had similar risks of cardiovascular diseases. Those who fulfilled the criteria for both IFG and IGT carried a greater risk of developing cardiovascular diseases that was not accounted for by differences in age, sex, or ethnicity.

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