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The prevalence of diabetes mellitus and its effect in elderly subjects in Hong Kong

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The prevalence of non-insulin-dependent diabetes mellitus in 1467 ambulatory elderly subjects aged from 60 to 90 years was determined using fasting plasma glucose as a screening test. A questionnaire survey on the history of diabetes and related complications was performed. The results showed that 10.7% had already been diagnosed as having diabetes mellitus. Screening revealed a further 5% who had diabetes mellitus but were asymptomatic. The prevalence of non-insulin-dependent diabetes mellitus was 15% (95% confidence interval 9-21) among the 60- to 80-year-old age group and 17% confidence interval (3 to 30) in those older than 80 years. Obesity and advancing age were adverse risk factors associated with diabetes. The diabetic subjects had significantly more coronary and cerebrovascular atherosclerosis, hypertension, and adverse lipid profiles. Even in the non-diabetic elderly subjects, fasting blood glucose was positively correlated with body weight and body mass index, confirming the importance of obesity in the aetiology of non-insulin-dependent diabetes mellitus. This is a common disease in the elderly and is associated with significant cardiovascular morbidity.

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Key words: Prevalence, Hong Kong; Diabetes mellitus; Aged

Introduction

There is growing evidence that the prevalence of non-insulin-dependent diabetes mellitus (NIDDM) in Hong Kong is similar to that of other Chinese subjects not living in China and is significantly higher when compared with those who reside in China.[1-5] This is believed to result from westernised lifestyle habits and changes in environmental factors so that the prevalence of diabetes mellitus (DM) in overseas Chinese is almost comparable to that in Caucasians.

As the population in Hong Kong is aging and DM is a chronic illness which is associated with multiple systemic complications, knowledge of the prevalence of DM and its characteristics would enable better planning of health care services for the elderly. Previous studies conducted in Hong Kong have shown that among adults of working age, the prevalence of DM was 5.1% in men and 3.6% in women. Increasing age and obesity were noted to be adverse predictive factors for the development of DM.[1] Another study performed in a confined community of approximately 400 elderly Hong Kong Chinese also demonstrated a high prevalence of DM—10% which increased to 17% in those older than 75 years.[2] In order to obtain a more representative elderly population, ambulatory subjects were recruited from different elderly day-centres in Hong Kong. The prevalence of NIDDM was determined and characteristics of DM subjects were compared with those of non-diabetic subjects.

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Subjects and methods

This was a joint project organised by the Departments of Medicine and Clinical Biochemistry, The University of Hong Kong, the Society for the Aged, and the Rotary Club of Hong Kong, Northwest. Members from seven community day-centres distributed over various parts of Hong Kong were invited to participate in a health-screening programme which included screening for DM. The participants were interviewed and a selected medical history was obtained. This included personal data, any previous diagnosis of DM, ischaemic heart disease, stroke, hypertension, use of medications, and smoking and alcohol consumption. For subjects with a complaint of chest discomfort, the Rose questionnaire for angina pectoris[6] was used for further assessment. Coronary heart disease was defined as a history of chest discomfort that complied with the criteria of the Rose questionnaire for angina pectoris, i.e. chest discomfort provoked by exertion and relieved by resting. A history of myocardial infarction was suggested by severe chest pain of more than half an hour's duration. In addition, subjects with a known history of coronary heart disease or on regular medications were also considered as having coronary heart disease. Furthermore, the participants were also invited to undergo a 12-lead electrocardiogram (ECG) to detect abnormalities including ischaemic changes which were graded according to the Minnesota Coding.

As elderly Chinese are often reluctant to accept repeated venepunctures required for an oral glucose tolerance test (OGTT), a fasting plasma glucose (FPG) of greater than 7.8 mmol/L was used as the screening test for a diagnosis of DM. We were unable to detect those with impaired glucose intolerance and those DM subjects with normal fasting values but elevated 2-hour post-glucose loading plasma glucose as defined by the World Health Organisation[7]. Subjects were tested after an overnight fast. Blood was drawn from an antecubital vein, kept at 4°C on ice and transferred on the same morning in an ice box to the laboratory where plasma was immediately separated and stored until assays were performed.

For the measurement of plasma glucose, blood was collected into fluoride tubes (1 mg/ml final concentration). For the measurement of lipid profile, blood was collected into EDTA tubes. Plasma glucose was measured using a hexokinase method (Hitachi 747 auto-analyser, Hitachi, Boehringer Mannheim, Germany). Total cholesterol (TC) and triglyceride (TG) were determined enzymatically on a Hitachi 717 analyser (Hitachi, Boehringer Mannheim,Germany). High-density lipoprotein cholesterol (HDLC) was quantified by the same enzymatic method after precipitation of very-low-density lipoprotein (VLDL) and low-density lipoprotein (LDL), with polyethylene glycol (PEG 6000). Low-density lipoprotein cholesterol was calculated according to the Friedwald equation.[8]

Statistical methods

Statistical analysis was performed using the Statistical Package for the Social Sciences. The results are expressed as mean standard deviation (SD). *t*-tests, X^2-test and analysis of variance (ANOVA) were used to compare the groups of subjects with raised fasting blood glucose, known DM, and control subjects. Pearson's correlation analysis was performed between the biochemical variables and demographic characteristics of the subjects.

Table 1. Prevalence of subjects with non-insulin– dependent diabetes mellitus

Age (y)	60-69	70-79	≥ 80
Total number of subjects (M/F)	684 (107/577)	650 (124/526)	133 (23/110)
Number with known DM (M/F)	80 (13/67)	63 (12/51)	15(4/11)
Prevalence of known DM	11.7 (5.8-17.5)%	9.7 (3.8-15.6)%	11.3 (0-24.4)%†
Number of newly-diagnosed DM (M/F)	29 (5/24)	37 (5/32)	8 (1/7)
Prevalence of newly-diagnosed DM	4.2 (0-9.7)%	5.7 (0-11.4)%	6.0 (0-18.7)%*
Total number of NIDDM	109	100	23
Prevalence of NIDDM	15.9 (9.9-21.8)%	15.4 (9.3-21.5)%	17.3 (3.6-30.9)%

* $P < 0.01$, ANOVA
† prevalence (95% confidence interval)

Results

A total of 1912 elderly subjects participated in the screening programme. However, only 1467 subjects (76.7%) had complete data for analysis. A total of 1213 women and 254 of these men were studied; 158 (10.7%) had a known history of DM—29 men and 129 women (Table 1). Fifty-one of these subjects had a raised FPG of more than 7.8 mmol/L on the day of assessment. The prevalence of known DM among these elderly subjects was similar for the three age groups.

Blood screening revealed 74 subjects who had undiagnosed DM with FPG values greater than 7.8 mmol/L—11 men and 63 women. The prevalence was similar in both sexes: women 63/1212 (5.2%) and men 11/255 (4.3%). However, the prevalence of newly diagnosed DM increased significantly with age (60 to 69 years: 4.2%, 70 to 79 years: 5.7%, older than 80 years: 6.0%, $P < 0.01$, Table 2). When all patients with DM were analysed, the prevalence for the 60- to 69-year age group was 15.9%, 70 to 79 years was 15.4% and in those older than 80 years was 17.3% (Table 1). The demographic and biochemical data of the 74 newly diagnosed diabetic subjects were compared with those of the 1235 non-diabetic elderly subjects, (Table 2). Newly diagnosed DM subjects were more obese, with greater body weight and body mass indices (BMI) (both $P < 0.005$). They also had more adverse lipoprotein patterns with higher fasting TGs, lower HDLC and higher risk factor ratios as defined by TC/HDLC. Otherwise, their TC and LDLC values were similar to those of non-diabetic subjects. Approximately 10% of the two groups of each group were chronic smokers. Their blood pressure and renal function were similar.

The data of the 158 subjects with a known history of DM were analysed and compared with those of the non-diabetic subjects (Table 3). The diabetic subjects were more obese, reflected by higher body weight ($P < 0.001$) and BMI values ($P < 0.01$). They had raised TG, lower HDLC and higher risk ratios compared with non-diabetic subjects. Although the DM

Table 2. Characteristics of subjects with newly-diagnosed diabetes mellitus compared with non-diabetic subjects

	Newly-diagnosed DM (n = 74)	Non-diabetic controls (n = 1235)	P value
Age (y)	70.8 (5.9)	70.5 (6.2)	ns
Sex (F/M)	11/64	214/1020	ns
Fasting blood glucose (mmol/L)	10.04 (2.37)	5.36 (0.67)	< 0.001
Smokers	10.5%	11.2%	ns
Body weight (kg)	60.11 (8.81)	56.31 (9.70)	< 0.005
Body mass index (m²/kg)	25.29 (3.53)	24.02 (3.83)	< 0.005
Systolic blood pressure (mmHg)	148 (21)	145 (21)	ns
Diastolic blood pressure (mmHg)	80 (16)	80 (11)	ns
Urea (mmol/L)	6.76 (1.38)	6.27 (1.42)	ns
Creatinine (μmol/L)	90.83 (7.56)	89.33 (8.13)	ns
Total cholesterol (mmol/L)	5.98 (1.10)	6.14 (1.11)	ns
Total triglyceride (mmol/L)	1.79 (0.76)	1.43 (2.20)	< 0.001
HDL-cholesterol (mmol/L)	1.25 (0.32)	1.43 (0.39)	< 0.001
LDL-cholesterol (mmol/L)	3.92 (0.95)	4.08 (0.71)	ns
TC/HDLC ratio	5.02 (1.27)	4.60 (1.38)	< 0.01

t-test, mean (SD)
ns = not significant

Table 3. Characteristics of subjects with known diagnosis of diabetes mellitus compared with non-diabetic subjects

	Known diagnosed DM (n = 158)		Non-diabetic controls (n = 1235)		P value
Age (y)	69.8	(6.2)	70.5	(6.2)	ns
Sex (M/F)	29/129		214/1020		
Fasting blood glucose (mmol/L)	11.24	(3.47)	5.36	(0.67)	< 0.001
Smokers	9.4%		11.2%		ns
Weight (kg)	59.1	(7.9)	56.3	(9.7)	< 0.001
Body mass index (m^2/kg)	24.83	(3.14)	24.02	(3.83)	< 0.01
Systolic blood pressure (mmHg)	150	(23)	145	(21)	< 0.005
Diastolic blood pressure (mmHg)	80	(11)	80	(11)	ns
Urea (mmol/L)	6.57	(0.98)	6.27	(1.42)	< 0.01
Creatinine (μmol/L)	89.79	(10.74)	89.33	(8.13)	ns
Total cholesterol (mmol/L)	5.9	(1.1)	6.14	(1.11)	< 0.01
Total triglyceride (mmol/L)	1.8	(1.1)	1.43	(2.20)	< 0.001
HDL-cholesterol (mmol/L)	1.30	(0.3)	1.43	(0.39)	< 0.001
LDL-cholesterol (mmol/L)	3.9	(1.0)	4.08	(0.71)	< 0.01
TC/HDLC ratio	4.83	(1.5)	4.60	(1.38)	< 0.05
ECG with ischaemic changes	13.1%		9.7%		< 0.02
Coronary artery disease*	11.8%		6.2%		< 0.0005
Hypertension*	43.0%		30.7%		< 0.001
Stroke*	6.5%		3.4%		< 0.02
Peptic ulcer disease*	9.2%		14.1%		< 0.05

t-tests, mean (SD)

* Known history

patients had lower TC and LDLC, this probably reflects the fact that some of these subjects were being treated for hyperlipidaemia. These subjects also had higher systolic blood pressure (SBP, $P < 0.005$) and urea levels ($P < 0.01$) than did the non-diabetic subjects but had similar diastolic blood pressure (DBP) and creatinine levels. Furthermore, these DM subjects had a higher prevalence of ischaemic changes on ECG ($P < 0.02$), known history of coronary artery disease ($P < 0.0005$), hypertension ($P < 0.001$), and stroke ($P < 0.02$) and a lower prevalence of peptic ulcer disease ($P < 0.05$) (Table 3).

Correlation studies were performed on the non-diabetic subjects which showed that FPG was positively correlated to body weight, BMI, DBP, SBP, TG, TC and TC/HDLC ratio and negatively correlated to HDLC (Table 4). We also noted that the smokers in the control group had higher creatinine levels than did the non-smokers [98.76 (9.62) vs 85.96 (7.54) μmol/L, $P < 0.001$].

The amount of physical activity undertaken by subjects with newly diagnosed DM was compared with that of the non-diabetics. This showed that fewer DM subjects walked up slopes or walked with heavy loads when compared with the controls (Table 5). Other daily activities were similar in both groups. An analysis of their eating and cooking habits did not reveal any major differences between the two groups (Table 6).

Table 4. Correlations of physical characteristics, blood glucose, and lipid profiles in 1235 non-diabetic subjects

	BW	BMI	DBP	SBP	TC	TG	LDL	HDL	Risk factor
FBG	0.190**	0.136**	0.123**	0.132**	0.105**	0.102**	ns	- 0.091*	0.145**
BW		0.715**	0.223**	0.159**	ns	0.172**	ns	- 0.354**	0.280**
BMI			0.173**	0.129**	ns	0.186**	ns	- 0.290**	0.244**
DBP				0.627**	ns	0.125**	ns	- 0.113**	0.133**
SBP					ns	0.117**	ns	ns	0.118**
TC						0.098*	0.164**	0.144**	0.399**
TG							0.619**	- 0.418**	0.577**
LDL								ns	0.326**
HDL									- 0.749**

* $P < 0.01$, ** $P < 0.001$

FBG= fasting blood glucose
BW= body weight
BMI= body mass index
DBP= diastolic blood pressure
SBP= systolic blood pressure

TC = total cholesterol
TG = total triglyceride
LDL = LDL-cholesterol
HDL = HDL-cholesterol
ns = not significant

Discussion

This survey documented that in ambulatory elderly subjects in Hong Kong, approximately 10% had already been diagnosed as having DM. Screening revealed a further 5% who had DM and were asymptomatic for their disease. The prevalence of NIDDM was approximately 15% in the 60- to 80-year age group and was more than 17% in those older than 80 years. This prevalence rate is comparable to that found in non-Chinese populations, e.g. 17% in White Americans, 25% in Black Americans and 10% in Danes.[9,10]

It has been recommended that the OGTT be used as the screening test for diabetes, as the sensitivity of FPG alone is lower, not including a plasma glucose 2-hour post-oral glucose load.[11] However, because of cultural reasons and the reluctance to undergo repeated venepunctures in the elderly Chinese population, a single blood sample was taken and OGTT was not performed. We believe that this represents an underestimation of approximately 3% in the prevalence of diabetes in the elderly. Cockram et al [12] evaluated the sensitivity of using FPG as a screening test, using a 2-hour, glucose level equal to or greater than 11.1 mmol/L as a diagnostic criteria for DM, and observed an increase in sensitivity from 40% to 57% if the cut-off for FPG was lowered from 7.8 mmol/L to 7.0 mmol/L. For our study population, the prevalence rate of the newly diagnosed DM would increase by 1% if we used 7.0 mmol/L as the cut-off for FPG. However, further evaluation of the screening test and diagnostic criteria for DM is required for our Chinese subjects.

Although the study subjects in this project were self-referred volunteers, we believe that they are representative of the elderly population in Hong Kong as they were recruited from seven different community day-centres distributed all over Hong Kong. Although there were significantly more women than men, it was known that elderly women socialise and participate more in community activities than do men in a ratio of 5.1:1.[13] The data obtained from this study agree well with those reported previously in a chosen community of 400 elderly subjects living in sheltered housing. However, whereas only one-third of their diabetic subjects were aware of the disease, this study, six years later, had revealed that two-thirds of the diabetic subjects had been previously diagnosed. Whether this dif-

Table 5. Amount of exercise regularly undertaken in newly-diagnosed diabetes mellitus patients

		Newly-diagnosed DM	Non-diabetic subjects	P value
Outdoor exercise/walking		85.1%	82.1%	ns
Walking upstairs		70.3%	60.3%	ns
Walking up slopes		57.3%	70.3%	<0.05
Walking with heavy loads		22.7%	34.7%	<0.01
Daily standing time	Nil	1.9%	3.4%	
		< half hour	16.6%	12.4%
	< 1 hour	24.2%	21.2%	ns
	≥ 1 hour	57.3%	63.0%	
Daily walking time	Nil	1.3%	1.1%	
		< half hour	10.2%	8.9%
	< 1 hour	22.9%	21.7%	ns
	≥ 1 hour	65.6%	68.3%	
Walking speed	very slow	5.7%	4.3%	
	slow	35.0%	30.1%	
	normal	46.5%	48.9%	ns
	brisk	12.7%	16.7%	
Outdoor walking (times/wk)		5.51 (1.26)	5.24 (1.86)	ns
Tai Chi (times/wk)		1.6 (2.41)	1.7 (2.85)	ns
Light housework (times/wk)		4.04 (1.45)	4.16 (1.32)	ns
Medium housework (times/wk)		3.71 (1.33)	4.39 (1.54)	ns
Heavy housework (times/wk)		0	0.62 (0.33)	ns

mean (SD)
ns = not significant

ference is due to increased public and professional awareness and increased health education provided by the community day-centres or whether it is due to possible differences in the socio-educational level of the two populations remains to be confirmed. A local study evaluating the effectiveness of adult health promotion did demonstrate that the participants were more knowledgeable and conscientious about their health and were healthier than their counterparts.[14,15]

The present study revealed that advancing age and obesity are adverse factors associated with DM. This study also suggested that the newly diagnosed DM subjects were less active than the control subjects. It has been shown previously that environmental factors such as obesity, physical inactivity, aging, dietary changes and urbanisation are important in the aetiology of NIDDM.[4] We were unable to demonstrate any major differences in the eating habits of the diabetic patients in the present study. However, as the design of the questionnaire was aimed only at detecting major differences in the distribution of carbohydrates, fat, and proteins in the diet as well as the style of cooking, further studies have to be performed in order to address the effect of dietary changes on the prevalence of DM in our population.

It is now generally accepted that NIDDM is associated with insulin resistance and hyperinsulinaemia rather than insulin deficiency. Furthermore, there is epidemiologic and clinical association between central obesity, impaired glucose tolerance or NIDDM, hypertension, dyslipidaemia, and disturbed fibrinolysis.[16] These cardiovascular risk factors, often grouped together as syndrome X, share a common root of hyperinsulinaemia.[17] The present study confirmed that the subjects with a known history of DM had significantly more coronary and cerebrovascular athero-

Table 6. Eating and cooking habits of the newly-diagnosed diabetes mellitus patients

	Newly-diagnosed DM	Non-diabetic subjects	P value
Taking fatty/oily food (more than once per week)			
Eating fried food	9.5%	11.7%	ns
Eating fatty meat	0%	4.1%	ns
Drinking creamy soup	23.8%	20.0%	ns
Squid/cuttle fish/shrimp/crab	0%	3.5%	ns
Internal organs	4.8%	1.8%	ns
Canned meat/fish	0%	3.1%	ns
Nuts	0%	10.7%	ns
Desserts	15.0%	14.8%	ns
Frequency of taking other foods			
Fruits (> once per week)	85.7%	85.9%	ns
Vegetables (daily)	100.0%	94.2%	ns
Rice (> one bowl per meal)	67.2%	75.9%	ns
Noodles (> one bowl per meal)	54.8%	62.7%	ns
Rice noodles (> one bowl per meal)	66.7%	67.4%	ns
Bread (> 2 pieces per meal)	85.7%	83.4%	ns
Cooking style (more than once per week)			
Fry	9.5%	4.9%	ns
Shuffle with oil	47.6%	51.0%	ns
Put on a hot oil layer	23.8%	27.1%	ns
Immerse in boiling water	23.8%	34.9%	ns
Cook with hot water	14.3%	25.0%	ns
Hotpot style	14.3%	23.0%	ns
Steam	81.0%	83.4%	ns

ns = not significant

sclerosis as well as more hypertension. Similarly, both known and newly diagnosed DM subjects had raised plasma TGs, lower plasma HDLC and higher BP recordings, all of these being atherogenic abnormalities associated with hyperinsulinaemia.

A more important observation in this study was that even in the non-diabetic elderly subjects, FPG was positively correlated with body weight and BMI, confirming the importance of obesity in the aetiology of NIDDM. Fasting plasma glucose was also positively correlated with BP recordings, plasma TG levels, and the TC/HDLC ratio and negatively correlated with HDLC in the non-diabetic subjects, i.e. the healthy elderly controls. Their BMI also correlated with both SBP and DBP. The correlations observed in these "healthy elderly controls" suggest that the concept of syndrome X is applicable to NIDDM patients and also to obese non-diabetic subjects.

The findings from this study confirm that NIDDM is prevalent among in the elderly in Hong Kong. With an estimated population of two million elderly in Hong Kong by the year 2000, understanding the problem of DM in this population will assist in the planning of health care systems for these patients and the installation of early preventive measures in the younger population. A programme of education emphasising healthy dietary habits, the need for exercise, and weight control will certainly be a most cost-effective form of prevention.

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