

## Effects of Age on Plasma Glucose Levels in Non-diabetic Hong Kong Chinese

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**Aim** To analyze the relationship between age and plasma glucose levels in Hong Kong Chinese population.

**Methods** We performed a cross-sectional study with 15 603 non-diabetic subjects from the community of Hong Kong. Plasma glucose concentration was measured in blood specimens from the subjects. The time of blood taking varied, depending on the availability of the patients.

**Results** There were 11 148 (71.4%) women and 4455 (28.6%) men (mean age:  $50.1 \pm 16.1$  years). There were 6901 (44.2%) patients who had plasma glucose measured in the fasting condition, 2999 (19.2%) who were 2-hour post-prandial, and 5703 (36.6%) who had plasma glucose measured at a random time. The correlation coefficients between age and plasma glucose levels in fasting, 2-hour post-prandial, and random group of patients were 0.159, 0.169, and 0.114, respectively (adjusted for body mass index, smoking, and gender; all *P* values <0.001). Fasting and random plasma glucose level increased by 0.15 mmol/L, while 2-hour post-prandial plasma glucose level increased by 0.26 mmol/L per decade-increase in age.

**Conclusion** Plasma glucose levels progressively increase with age in Hong Kong Chinese non-diabetic subjects.

Diabetes mellitus is nowadays reaching epidemic proportion in many parts of the world (1). Although the development of hyperglycemia is multi-factorial, insulin resistance and impairment in pancreatic insulin secretion have been among the most commonly reported pathogenetic mechanisms associated with diabetes (2). Aging is thought to be one of the most important factors that affect these mechanisms (3-5).

Insulin secretion can be decreased as a consequence of progressive organ impairment which often happens in the old age and can affect the pancreas. On the other hand, aging is one of the major causes for developing insulin resistance (3,4). However, despite the widely reported higher prevalence of diabetes among the elderly, the information on the relationship between age and plasma glucose levels is relatively limited.

In this study, we aimed to analyze the relationship between age and plasma glucose levels in 15 603 non-diabetic Hong Kong Chinese.

### Subjects and methods

In this survey, performed in the period between April 1996 and August 1997, we recruited 17 242 adult subjects from the community of Hong Kong. The methodology has been reported before (6). Volunteer participants came to the United Christian Nethersole Community Health Service (UCHCNS) Centers for health assessment. UCNCHS is a self-funded, non-profit organization with the objective of health promotion through primary health care and education. Participants came from different districts all over Hong Kong. All of them gave verbal informed consent before the examination was performed.

Participants were interviewed and examined by a nursing officer and a clinician. Demographic data, and past and present medical history were collected. Demographic data, including height and weight (measured to the nearest 0.1 kg) and blood pressure, were obtained following the stan-

dard protocol, with the subject in light clothing without shoes. Blood pressure was measured on the right arm with a standard mercury sphygmomanometer. The Korotkoff sound V was taken as the diastolic blood pressure.

Blood specimens were taken from all participants. The timing of blood taking varied depending on the availability of the patient. According to the time of blood sampling, there were three types of plasma glucose samples. Fasting plasma glucose was measured after overnight fasting for at least 10 hours, 2-hour post-prandial plasma glucose was measured 2 hours after a meal of usual quantity, and random plasma glucose was collected in the time periods other than fasting or 2-hour post-prandial. Plasma glucose was measured by a hexokinase method (Hitachi 911, analyzer Boehringer Mannheim, Mannheim, Germany). The intra-assay coefficient of variation (CV) of glucose was 2% at 6.6 mmol/L.

### Statistical analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences for Windows, Version 10.0 (SPSS Inc., Chicago, IL, USA). All results were expressed as mean $\pm$ SD or n (%), where appropriate. Body mass index, smoking, and gender adjusted partial correlation coefficient (*r*) was used to assess the correlation between age and plasma glucose levels. Regression analysis with age as dependent variable was performed to predict the relationship between age and plasma glucose. All analyses involving age used original values. However, in result presentation, age categorization (in decades) was used where appropriate to facilitate the interpretation. *P*-value <0.05 was considered statistically significant.

### Results

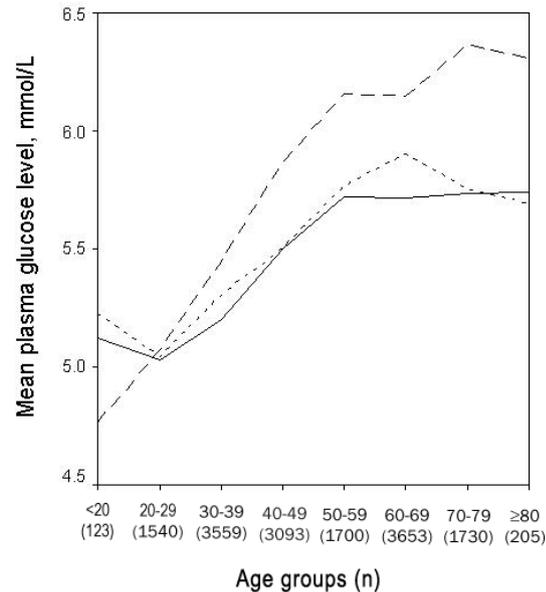
Out of 17 242 subjects, 1639 (9.5%) were excluded due to the lack of data on plasma glucose

levels or because they were diabetics and taking medications that might affect the plasma glucose level. Out of 15 603 subjects included into the analysis, there were 11 148 (71.4%) women and 4455 (28.6%) men. Mean age was  $50.1 \pm 16.1$  years (median: 48.0 years, range: 12.7-96.0 years). Fasting plasma glucose was measured in 6901 (44.2%) subjects, 2-hour post-prandial plasma glucose in 2999 (19.2%) subjects, and random plasma glucose in 5703 (36.6%). Table 1 summarizes the clinical characteristics of these subjects.

**Table 1.** Clinical characteristics and the increase in plasma glucose level per decade-increase in age of the 15 603 Hong Kong Chinese subjects categorized according to their plasma glucose measurement status

Characteristic	Plasma glucose measurement status		
	fasting (n=6901)	2-hour (n=2999)	random (n=5703)
Mean age (years $\pm$ standard deviation)	48.9 $\pm$ 15.8	47.1 $\pm$ 15.1	53.1 $\pm$ 16.4
Women (n, %)	4922 (71.3)	2081 (69.4)	4145 (72.7)
Smokers (n, %)	1063 (15.4)	459 (15.3)	861 (15.1)
Body mass index (kg/m <sup>2</sup> )	23.1 $\pm$ 3.6	23.0 $\pm$ 3.6	23.2 $\pm$ 3.6
Systolic blood pressure (mmHg)	120 $\pm$ 23	118 $\pm$ 22	123 $\pm$ 24
Diastolic blood pressure (mmHg)	76 $\pm$ 11	74 $\pm$ 11	76 $\pm$ 11
Plasma glucose (mmol/L)	5.47 $\pm$ 1.25	5.78 $\pm$ 1.79	5.61 $\pm$ 1.73

There were significant positive correlations between age and plasma glucose after the adjustment for body mass index, smoking, and gender. The *r* coefficients between the age and fasting plasma glucose, 2-hour plasma glucose, and random plasma glucose were 0.159, 0.169, and 0.114, respectively ( $P < 0.001$ ). Plasma glucose changed with age in the 3 groups of subjects (Figure 1). Using regression analysis with age (decade) as the dependent variable to predict plasma glucose level in the fasting plasma glucose group, the following equation was derived: plasma glucose =  $(0.154 \times \text{age}) + 4.72$  [model summary: adjusted  $R^2 = 0.038$ ,  $F = 274.2$ , overall significance  $< 0.001$ , 95% CI of slope =  $(0.152, 0.156)$ ]. According to this equation, every decade-increase in age is associated with 0.154 mmol/L increase in the fasting plasma glucose level (men: 0.140 mmol/L; women 0.159 mmol/L). Likewise, equations for 2-hour plasma glucose and



**Figure 1.** Changes of mean plasma glucose levels with age of 15 603 Hong Kong Chinese subjects categorized according to their plasma glucose measurement status.

random plasma glucose were: 2-hour plasma glucose =  $(0.263 \times \text{age}) + 4.54$  [model summary: adjusted  $R^2 = 0.049$ ,  $F = 154.8$ , overall significance  $P < 0.001$ , 95% CI of slope =  $(0.259, 0.267)$ ]; random plasma glucose =  $(0.149 \times \text{age}) + 4.81$  [model summary: adjusted  $R^2 = 0.020$ ,  $F = 117.4$ , overall significance  $< 0.001$ , 95% CI of slope =  $(0.147, 0.151)$ ], respectively. Hence, every decade-increase in age is associated with 0.263 mmol/L increase in the 2-hour plasma glucose level (men: 0.191 mmol/L; women 0.282 mmol/L) and 0.149 mmol/L increased in the random PG, respectively (men: 0.091 mmol/L; women 0.167 mmol/L).

## Discussion

Data presented here should be interpreted with caution, since we analyzed a sample of volunteer participants who might be more aware of their health and consequently “healthier” than the general population. To minimize heterogeneity of the data, we also excluded diabetic subjects from our analysis. Hence, our results can only apply to non-diabetic normal population. In addi-

tion, this sample may not accurately represent the Hong Kong Chinese, since the sample was skewed in such a way that more than 70% were women.

Information on the relationship between age and plasma glucose is relatively limited. We have previously reported, in a survey of 1513 subjects, that the glycated hemoglobin (HbA<sub>1c</sub>) levels increased progressively with age (7). A similar finding was reported by Kilpatrick et al (8) who reported that mean HbA<sub>1c</sub> rose from 3.82% to 4.44% in 232 non-diabetic subjects between the age of 20 and 70. However, in the same study, fasting plasma glucose levels showed no relationship with age. This negative finding is likely due to the small sample size. In our study with more than 15 000 subjects, although the correlation coefficients were not too high, we observed a very clear and significant increase in plasma glucose levels with age. This finding applies to fasting; 2-hour post-prandial, as well as random plasma glucose levels, with 2-hour plasma glucose showing the strongest relationship.

In a recent study done in India, Kutty et al (9) reported lower plasma glucose levels in the young age group (20-29 years) and higher plasma glucose level in the old age group (>69 years) in women than in men. In addition, the increment of plasma glucose per decade was almost twice as high in women as in men. Similar to their finding, we observed a more significant increase in plasma glucose level per decade in women than in men. Women in the random plasma glucose group had 80% higher increase in plasma glucose level per decade than men (0.167 vs 0.091). This may be accounted by a rapid deterioration in insulin resistance-in women after menopause. However, the exact mechanism is still elusive.

The increase of plasma glucose with an increasing age is believed to be multi-factorial. It has been suggested that age could affect the glycemic index values of foods. However, there is a lack of data to support this notion, and a recent

study concluded that the glycemic index for lentils was not affected by age (10).

Insulin levels have been reported to be decreased, stable, or even increased with advancing age (5,11-13). However, the elevated insulin level among the elderly with apparent hyperinsulinemia can be attributed to a combination of hyperproinsulinemia and reduced metabolic clearance of insulin (4,11,12). Their disproportionate high proinsulin to C-peptide levels suggested impairment in pancreatic beta-cell function.

On the other hand, insulin sensitivity has been reported to decrease with age (3,4,14,15). Insulin resistance associated with aging has been suggested to be associated with age-related decline in serum dehydroepiandrosterone sulfate (DHEA) level (16,17), which is a hormone that can reduce visceral fat accumulation and improve insulin resistance. An increase in other stress hormones, such as plasma cortisol, may also play a role in the age-associated hyperglycemia (18).

In conclusion, plasma glucose levels increased with age in the Hong Kong Chinese. For every decade of increase in age, there was a 0.15 mmol/L increase in fasting and random plasma glucose level and 0.26 mmol/L increase in 2-hour post-prandial plasma glucose level. A better understanding of the metabolic derangements in aging population is essential for adequate preventive measures.

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