ORIGINAL ARTICLE

Blood Glucose and Glycosylated Haemoglobin in Malays and Aborigines in Malaysia

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Summary

Fasting blood glucose (FBG) and glycosylated haemoglobin (HbA1) were determined in 1136 subjects aged 7 and above amongst the Aborigines and Malays living in three different socio-economic environments in Malaysia. FBG was measured using a Reflotron glucose analyser and HbA1 by a microcolorimetric method. There was no difference in FBG between Aborigines and Malay children aged between 7-17 years old. However, there was a significant difference in the mean FBG between the two races amongst the adults ($p = 0.0007$). The Malays who lived in rural and urban areas had a higher percentage of subjects with FBG more than 6 mmol/l compared to Aborigines at all locations. For HbA1, significant differences between races were found in both children and adults ($p = 0.0001$). FBG correlated with body weight, body mass index, skinfold thickness and cholesterol in adults. However, using multiple regression, only age, gender, and skinfold thickness correlated with FBG. Body mass index was an important predictor for HbA1 in children whereas in adults, HbA1 levels were only a function of age and socio-economic factors.

Key Words: Fasting blood glucose, Glycosylated haemoglobin, Aborigines, Malays

Introduction

Fasting blood glucose (FBG) and oral glucose tolerance tests (OGTT) have been used to diagnose diabetes for many years. OGTT when performed properly is an excellent method of evaluating glucose disposal following an oral glycaemic challenge. Although the fasting blood glucose is valuable, it can be misleading especially when the value is normal[1]. As OGTT may be difficult to perform in young children, FBG has been used to evaluate glucose tolerance among this group. Although, glycosylated haemoglobins A1c (HbA1) has been shown to be a useful parameter to reflect the quality of glycaemic control[1,2,3,4] it is not sensitive enough as screening test for diabetes[5].

Due to rapid socio-economic progress in Malaysia, changes in cultural values, nutrition and lifestyle of the people are inevitable especially in rural areas. The aims of this study were to determine the levels of blood glucose and HbA1 in two populations at different stages of socio-economic development and to examine some risk factors related to these two variables. Such information gathered would be useful in planning a definite strategy to control hyperglycemia and achieve our ultimate aim in prevention of diabetes mellitus.

Materials and Methods

A total of 1136 samples comprising 430 subjects aged between 7-17 years old and 706 subjects aged 18 years and above were selected using cluster sampling from six locations in Malaysia based on their socio-economic status. The details of locations and sampling procedures had been described elsewhere[6]. Four of these locations were situated in the central mountainous region of Central Pahang, and two were around Kuala Lumpur, the national capital in Federal Territory. These were Ulu Sungai traditional Malay village, Sungai Koyan land development scheme, Lanai traditional Aborigine village, Betau Aborigine resettlement scheme, Kampong Kerinci Malay area in Kuala Lumpur and a modern Aborigine village at the fringe of the city.

Survey procedures

Subjects were informed by house to house visit or by a letter, a day prior to examination to come for oral glucose tolerance test in our mobile clinic. They were instructed not to take any meal 10 hours prior to the examination to be done early the next morning at 8.00 am. After registration, 10 ml of venous blood was taken by venepunture from each subject. Fasting blood glucose (FBG) was measured by using Haemoglucotest strip and Reflotron glucose analyser (Boehringer Mannheim). The analyser was validated by using Beckman's glucose analyser, from the same blood samples, in the laboratory. Oral glucose tolerance test was conducted only amongst adults. Four drops of blood were placed on filter paper for determination of HbA1 using microcalorimetric method that had been developed in our laboratory[7]. Serum were also used for determination of cholesterol and albumin levels. The subjects were then weighed using calibrated SECA spring balance and their height measured using microtoise. Mid-arm circumference (MAC) was measured by using flexible tape and skin fold thickness at the supra iliac (SISFT) and tricep (TSFT) regions by using Harpenden caliper. The subjects were also interviewed by a dietician to assess their dietary intake by using 24-hour dietary recall.

Statistical procedures

Statistical analysis was done using SAS statistical software release 6.3 (SAS Institute Inc). In order to compare groups according to FBG and HbA1 and its relationship with nutritional parameters, Chi-square test, student's t-test and analysis of variance were used. In all calculations, the criterion of significance was $p < 0.05$. To be able to determine the associations between FBG and HbA1 and various risk factors, categorisation applied : ethnic, orang Asli(1) Malays(2); urbanisation, urban (1) rural (2); sex, male (1) female (2); activity, light (1) moderate and heavy (2).

Results

Fasting blood glucose in children

There was no significant difference in the distribution of fasting blood glucose between the Aborigines (better known as orang Asli) and Malay children (p= 0.16) (Table I). However, children in rural areas especially Aborigine children had higher levels of FBG compared to children in urban areas. There was a highly significant difference in the levels of FBG between Post Lanai (Aborigines) and Kampung Kerinci (Malay) children aged 7-17 years old (ANOVA F=3.68, p=0.0029) (Table II). Overall, the mean levels of FBG varied significantly according to location (Table II and Figure 1).

There was no significant difference in the levels of FBG in children according to age and gender (p=0.89) (Table I) as well as to their nutritional status either using body mass index or Waterlow classification to classify nutritional status (Table III). With the exception of fat intake, none of the nutritional indices correlated with FBG (Table IV). There was no factor that could predict the level of FBG in children.

Fasting blood glucose in adults

In adults, there were more Malays living in either urban or rural areas who had FBG above 6 mmol/l compared to the orang Asli in most of the locations studied (p=0.0007) (Table I). Study shows that there was a significant difference in the levels of FBG among adults between Hulu Sungai and Kampung Kerinci with Post Betau (F=3.98, p=0.0015) (Table II). The level of FBG did not differ according to the degree of urbanisation. In terms of age and gender, there was a significant difference in the mean FBG in adults aged less than 40 compared to those aged 40 years and above (Table I). Females had higher levels of FBG compared to males even after adjusting for age. Mean FBG among Malay females was higher compared to orang Asli women; however no difference was observed among men. In term of activity, there was a significant difference in FBG according to daily activities (Table I). The difference between light versus moderate and heavy activities was significant (p = 0.02).

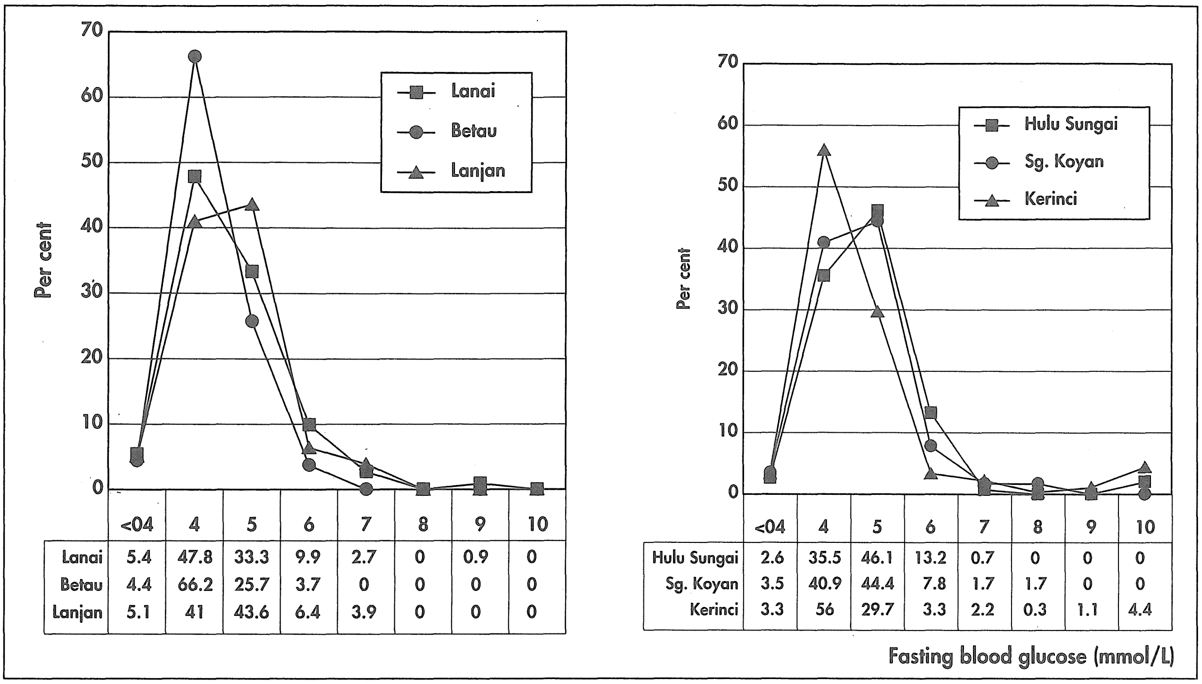
Table I
The association between fasting blood glucose and HbA1 among children and adults (p values)

Factors	Children		Adults	
	FBG	HbA1	FBG	HbA1
Ethnic	0.16	* <0.0001	* 0.0007	* <0.0001
Urbanisation	* 0.02	* 0.03	0.29	* 0.02
Age	0.89	0.15	* <0.0001	* <0.001
Sex	0.32	* 0.02	* 0.01	* 0.03
Weight	0.24	0.95	* 0.01	* <0.0001
Height	0.54	0.39	0.69	0.07
MAC	0.67	0.56	0.10	* <0.001
SISFT	0.88	0.88	* <0.001	* <0.0001
TSFT	0.40	0.64	* 0.02	* <0.0001
Energy intake	0.33	0.56	0.54	0.99
Protein	0.49	0.05	0.74	0.27
Carbohydrate	0.39	0.38	0.40	0.40
Fats	0.05	0.50	0.72	* <0.01
Activity	0.40	0.22	* 0.02	0.05

** p values indicate the significant difference between the levels of FBG or HbA1 with various factors at 0.05.*
SISFT = supra iliac skinfolds, TSFT = tricep skinfolds
MAC = mid arm circumference

The cut off points applied for the children and adults were as follows: age in years (13,40); weight in kg (27,50); height in cm (130,150); MAC in cm (18,27); SISFT in cm (10,15); TSFT in cm (15,20); Energy in KCal (1200, 1500); Protein in g (45,50); Carbohydrate in g (200,250); Fats in g (25,25).

In adults, FBG differed significantly according to body weight in which body weight of greater than 50 kg had mean FBG of 5.23 mmol/l compared to 5.0 mmol/l for those with weight of less than 50 kg. Supra iliac and tricep skin folds thicknesses also showed a significant difference. Other nutritional indices such as height and midarm circumference did not have significant association with FBG (Table I). There was no significant difference in the levels of FBG according to energy, protein, carbohydrate and fat intake (Table I). In term of



	<04	4	5	6	7	8	9	10
Lanai	5.4	47.8	33.3	9.9	2.7	0	0.9	0
Betau	4.4	66.2	25.7	3.7	0	0	0	0
Lanjan	5.1	41	43.6	6.4	3.9	0	0	0

	<04	4	5	6	7	8	9	10
Hulu Sungai	2.6	35.5	46.1	13.2	0.7	0	0	0
Sg. Koyan	3.5	40.9	44.4	7.8	1.7	1.7	0	0
Kerinci	3.3	56	29.7	3.3	2.2	0.3	1.1	4.4

Fig. 1: Fasting blood glucose according to location

Table II
Fasting blood glucose and HbA1 levels according to locations among children and adults

	Children			Adults		
Location	n	FBG mean	HbA1 mean	n	FBG mean	HbA1 mean
Aborigines:						
a. Post Lanai	60	*f 5.2	4.6	111	5.0	*def 4.5
b. Post Betau	64	*d 5.0	4.1	136	*e,f 4.8	*def 4.4
c. Bkt. Lanjan	63	4.9	4.7	73	5.1	*def 4.8
Malays:						
d. Hulu Sungai	52	5.1	6.2	152	5.4	5.5
e. Sg. Koyan	113	4.9	5.6	114	5.1	5.6
f. Kg. Kerinci	53	4.8	5.1	90	5.3	5.8
ANOVA TEST	F	3.68	13.11		3.98	17.4
	p	0.0029	0.0001		0.0015	0.001

* *significantly difference from marked areas (a to f)*

Table III
The relationship between fasting glucose levels and HbA1 with BMI among children

Indices	Nutritional status	Fasting blood glucose (mmol/l) n	Fasting blood glucose (mmol/l) mean	HbA1 (%) n	HbA1 (%) mean
BMI	Moderate malnutrition	146	4.9	111	5.16
	Mild malnutrition	145	5.0	120	5.12
	Normal	112	5.0	86	4.83
Analysis of variance (ANOVA)		F = 0.91, p = 0.4		F = 1.37, p = 0.26	
Waterlow class	Wasted	71	5.1	80	5.18
	Stunted	109	5.0	61	4.89
	Wasted & stunted	110	5.0	88	4.94
	Normal	115	4.9	88	5.12
ANALYSIS of variance (ANOVA)		F = 1.98, p = 0.11		F = 0.76, p = 0.52	

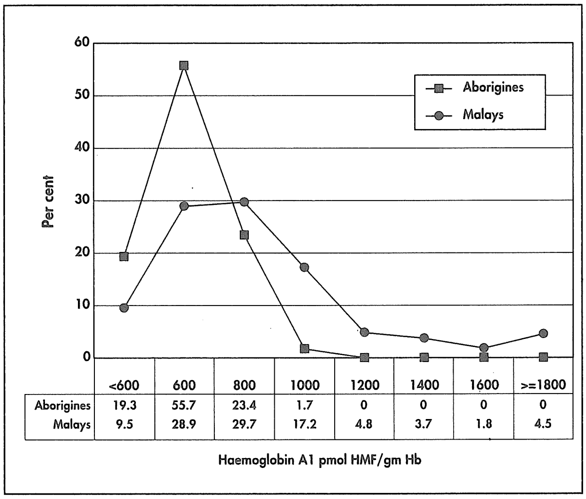


Fig. 2 : Haemoglobin A1 according to ethnic group

correlation, FBG was positively correlated with weight, supra iliac and tricep skin fold thicknesses, body mass index and cholesterol levels (Table IV) but no correlation was found with height and nutrient intakes. There was a significant and negative correlation between albumin levels and FBG in adults. Even though there were significant correlations between FBG and the factors studied, the correlations were not strong (r between 0.1 to 0.2 only).

Using multivariate analysis, it was found that gender, age and SISFT were independent variables that could predict FBG levels (F= 19.6 and p=0.0001). The regression formula was :

FBG = 3.68 + 0.02 (age) + 0.25 (gender) + 0.02 (SISFT).

Glycosylated haemoglobin in children

The pattern of distribution of glycosylated haemoglobin A1 (HbA1) was almost similar to FBG. A higher percentage of Malay children had HbA1 values of greater than 8 umol/gm Hb compared to orang Asli (Table I and Fig. 2). The mean HbA1 concentration in Malay children was significantly different compared to that for orang Asli (p=0.0001) (Table I). The mean HbA1 concentration was also significantly different between Malays and orang Asli depending on their socio-economic locations (F=13.1, p=0.0001) (Table II and Fig. 3). Study shows that the levels of HbA1 were dependent on the status of urbanisation. However, contrary to normal belief,

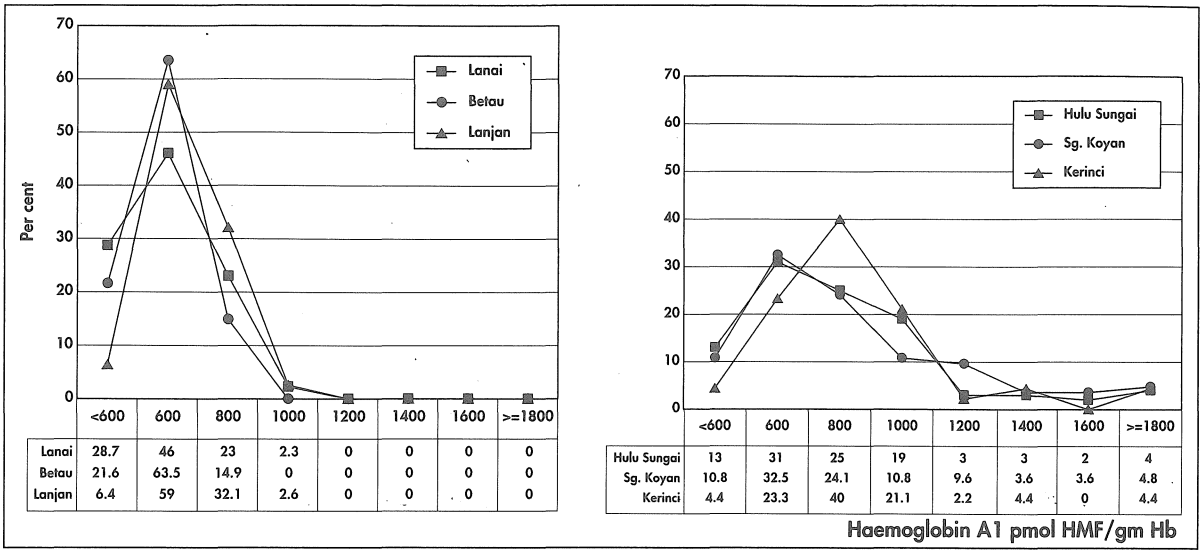


Fig. 3: Haemoglobin A1 according to location

Table IV
Correlation between FBG and HbA1 with nutritional indices and nutrient intakes

	Children 7-17 years				Adults			
	FBG		HbA1		FBG		HbA1	
	r	p	r	p	r	p	r	p
Weight	-0.011	0.821	0.041	0.469	0.092	0.02	0.238	0.0001
Height	0.022	0.664	0.1	0.076	0.018	0.64	0.157	0.0004
BMI	-0.019	0.697	-0.055	0.331	0.094	0.014	0.183	0.0001
TSFT	-0.092	0.068	0.052	0.359	0.109	0.005	0.270	0.0001
SISFT	-0.061	0.225	0.122	0.032	0.17	0.0001	0.282	0.0001
MAC	0.004	0.94	-0.039	0.49	0.085	0.03	0.222	0.0001
Albumin	-0.01	0.867	0.153	0.039	-0.116	0.013	-0.067	0.234
Cholesterol	-0.079	0.198	0.349	0.001	0.133	0.004	0.265	0.0001
Energy	-0.06	0.224	-0.067	0.236	0.03	0.44	0.044	0.333
Protein	-0.023	0.654	0.038	0.515	-0.01	0.75	0.037	0.414
CHO	0.003	0.955	0.051	0.373	0.008	0.85	-0.018	0.684
Fats	-0.117	0.021	-0.057	0.319	0.044	0.26	0.13	0.004

higher levels of HbA1 were found among the children living in the rural areas compared to those in the urban. The levels of HBA1 did not changed by age in children. However, males was found to have significantly higher HBA1 as compared to females.

There was no significant difference in the levels of HbA1 according to the physical activity and nutritional status in children (Table I). Nutritional indices either singly (body weight, skin fold thickness and mid-arm circumference) (Table I) or in combination (body mass

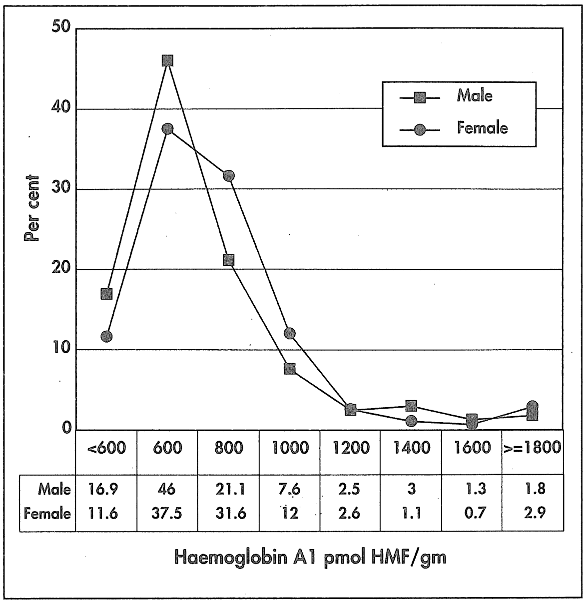


Fig. 4: Haemoglobin A1 according to gender

index and Waterlow classification of malnutrition) (Table III) was not found to have a significant association with HbA1. However, there was a significant and positive correlation between HbA1 and the levels of cholesterol in children (p=0.0001) (Table IV).

For the determination of HbA1 in children, ethnicity and body mass index (BMI) were a significant factors in regression model (n=316, r^2=0.147, F=18.0 and p=0.0001). The formula was :

$$HbA1 = 4.73 + 1.11(ethnic) - 0.006(age) - 0.29(BMI).$$

Glycosylated haemoglobin in adults

The mean HbA1 concentration in Malay adults was also significantly different compared to that for orang Asli (p=0.0001) (Table I). The concentration was also significantly different according to their socio-economic locations (F=17.4, p=0.001) (Table II and Fig. 3). Higher levels were found among urban community especially Malays.

There was a significant difference in the levels of HbA1 by age. Adults aged 40 years old and above had higher HbA1 compared to those aged less than 40 years ($p < 0.001$) (Table I). In terms of gender, adult Malay females had significantly higher level of HbA1 compared to orang Asli females (p=0.01), but there was no difference in the levels of HbA1 among men (Fig. 4).

There was a significant difference in the levels of HbA1 according to the physical activity in adults (F=7.58, p=0.0006). The mean levels of HbA1 among adults performing daily light activities were 5.3%, moderate activities 5.1% and heavy activities 4.4%. With exception of height, all other nutritional indices were found to have a significant association with HbA1 (Table I and Table III). However, only fats intake was associated with the levels of HbA1 in adults (Table I). In terms of correlation, HbA1 correlated significantly with body weight, height, mid-arm circumference, skin fold thicknesses, body mass index, cholesterol levels and fats intake.

For the adults, ethnicity, age and urbanisation were the factors that could predict the level of HbA1 (n= 484, r^2 =0.167, F=30.7 and p=0.0001) using the formula ;

$$HbA1=2.65+1.05(ethnic)+0.01(age)+0.4(urbanisation)$$

Discussion

This study found that the mean fasting blood glucose level and HbA1 were significantly lower in the Aborigines compared to the Malays. The mean FBG was also found to be higher in females compared to males, and in subjects greater than 40 years of age. The mean levels of FBG in the Thai population were also increased with increasing age and were higher in the females[8]. In that study, age, BMI, cholesterol and blood pressure correlated significantly with FBG in both males and females. The differences in blood glucose levels according to gender were not found in other studies[9,10]. The increase in FBG according to age did not depend on BMI and increments of 0.7 mg/ml among women were reported in several studies[9,10]. The increase in FBG according to age could be due to "aging process"[11]. Daily physical activities were also linked to the level of FBG in adults, whereby light activities were associated with a higher mean level of FBG. With the exception of body weight, all nutritional indices and intake did not show any relationship with FBG. In Thai population, BMI was an independent predictor for FBG[8]. Another study showed a significant association between FBG and fat intake in women and carbohydrate in men[11]. Even though supra iliac skin fold thickness (SISFT) did not show any significant relationship in univariate analysis, after controlling for the effect of other variables, SISFT was able to predict FBG. In the NHANES II study, sub scapular skin fold thickness was found to be more predictive after controlling for age[12]. These indicate the importance of fat deposition sites in relation to glucose intolerance compared to total body fat as shown by BMI.

There was a strong correlation between FBG and HbA1 ($r=0.8$, $p < 0.001$) and the distribution pattern was almost similar. However, the mean level of HbA1 was significantly different according to body weight, BMI, midarm circumference, supra iliac and tricep skin folds thickness. BMI was the main factor in predicting the level of HbA1 after controlling the effect of ethnicity and gender. HbA1 is a glycohemoglobin that correlates to the integrated blood glucose level of the preceding 2-3 months, making it useful for blood glucose monitoring among diabetics[1,2]. HbA1 levels are usually higher among diabetics compared to normal individuals[13,14,15]. In the present study, HbA1 levels were different according to ethnic, gender and urbanisation in adults as well as in children. However, in children, HbA1 levels were not associated with nutritional status. In adults, nutritional status was the important factor determining the blood glucose levels FBG or by HbA1. The low levels of HbA1 among the rural population could be due to malarial infection, especially among the Aborigines in the jungles, which shortened the life span of red blood cells. On the other hand, higher levels of FBG and HbA1 among the Malays could be due to better nutrition and red blood cells survival. However in some cases this has lead to development of diabetes mellitus and IGT. In conclusion, this study showed that Malays were more prone to IGT and diabetes compared to Aborigines, as manifested by higher levels of FBS and HbA1. This may be due to their affluent lifestyles, over eating, higher intake of animal fats and less physical activities.

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