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Genetics, Obesity, and Environmental Risk Factors Associated with Type 2 Diabetes

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Aim To determine the association between consanguineous marriages, obesity, and environmental risk factors associated with type 2 diabetes, in the adult Qatari population.

Methods The case-control study was carried out among diabetic patients and healthy subjects at the Primary Healthcare Clinics (PHCs) and the survey was conducted from February to November 2003.The study included 338 cases (with diabetes) and 338 controls (without diabetes). Face-to-face interviews were based on a questionnaire that included variables such as age, gender, socioeconomic status, parity, income level, cigarette smoking, physical activity, body mass index (BMI), obesity, and lifestyle. Their health status was assessed by medical conditions, family history, physical examination, blood pressure, blood glucose, blood count, lipid profile, cholesterol total, HDL, LDL, and triglycerides analysis.

Results The mean age (in years ± standard deviation) of cases versus controls was 45.5 ± 8.9 vs 42.4 ± 8.0, $P<0.001$. The study revealed that there were statistically significant differences between diabetic and control subjects with respect to body mass index, low educational level, consanguineous marriage, and number of children ($P<0.001$). The obesity was considerably more frequent among diabetes subjects ($P<0.001$). Self reported family history (in first degree relatives) of diabetes (62.1% vs 44.4%, OR = 2.06, 95% confidence interval (CI) = 1.49-2.83) $P<0.001$) was prominent among diabetic subjects. The diabetes was significantly common among the consanguineous marriages of the first degree relatives compared with the control group (33.1% vs. 24.6%, OR = 1.59, 95% CI = 1.11-2.29), $P=0.008$). Systolic blood pressure ($P=0.023$) and glucose fasting ($P<0.001$) levels were significantly higher in diabetic patients than in control subjects. The logistic regression model showed that smoking (OR = 2.42 95% CI = 1.66-3.54, $P<0.0001$); degree of consanguinity (OR = 1.38 95% CI = 1.13-1.69, $P=0.002$), BMI (OR = 1.41 95% CI = 1.12-1.76), $P=0.003$), level of education (OR = 1.23 95% CI = 1.04-1.45, $P=0.017$), number of children (OR = 1.34 95% CI = 1.02-1.77, $P=0.037$), and systolic blood pressure (OR = 1.01 95% CI = 1.00-1.02, $P=0.044$) were considered as associated risk factors for diabetes.

Conclusion The present study revealed that obesity, consanguinity, blood pressure, total cholesterol, HDL-cholesterol, and triglycerides were more prevalent in diabetic patients. The characterization of these factors will contribute to defining more effective and specific strategies to screen for and control diabetes and cardiovascular disease in a developing country.

Qatar, like many other developing countries, has witnessed a rapid change in many aspects of life during the last two decades. There has been a dramatic improvement of the national economy in terms of per capita income. These dramatic changes have had a great impact on urbanization and lifestyle of the Qatari community and as a result, diabetes mellitus has become the main public health problem.

The prevalence of type 2 diabetes has been rising worldwide (1). In particular, epidemics of this disorder have taken place in developing societies (2), with the highest prevalence recorded among the Pima Indians of Arizona, USA (3). In the developed and rapidly modernizing countries, there has been an increasing concern about the impact of type 2 diabetes on health services (4-8). The increasing prevalence of this disorder in the modern world has been attributed to an unmasking of genetic defects by environmental factors brought about by changes in lifestyle (9-12). Type 2 diabetes mellitus is a common multifactorial genetic syndrome, which is determined by several different genes and environmental factors (8-12). From a metabolic viewpoint, the most accepted model for the development of type 2 diabetes involves an interaction of insulin resistance with hyposecretion of insulin (13), but which abnormality comes first is still a matter of debate (14). Most investigators, however, believe that insulin resistance plays a predominant role in the pathogenesis of type 2 diabetes (15). In some populations, however, the role of insulin resistance has been questioned when high insulin sensitivities were found in a large proportion of subjects with type 2 diabetes (16). Another common belief is that type 2 diabetes is only one component of a more generalized metabolic syndrome (Syndrome X, ref. 17) which is caused by insulin resistance and/or hyperinsulinemia, and encompasses hypertension, dyslipidemia, and susceptibility to coronary heart disease (18). This viewpoint however, may not be true in all populations (19). In addition, a significant correlation between hyperinsulinemia and hyperuricemia does exist (19-22). The rising prevalence of non-insulin-dependent diabetes mellitus in developing societies has been attributed to an unmasking of genetically determined insulin resistance by a modern lifestyle.

The aim of this study was to determine the association between consanguineous marriages, lifestyle-habits, obesity, and environmental risk factors associated with type 2 diabetes in the adult Qatari population.

Subjects and Methods

This was a case-control study, designed to determine the relationship between type 2 diabetes, genetic factors, and life-style risk factors among the adult Qatari population between 25 and 65 years of age. The study was conducted in a period from February to November 2003.

Selection of Diabetic Subjects

Persons were classified as diabetics if their venous blood glucose values were ?7.0 mmol/L or if they were currently taking diabetic medication (1). A total number of 338 diabetic Qatari patients aged 25-65 years was selected by a simple random method from Primary Health Care Centers. Their health status was assessed by recording previous medical conditions, family history, physical examination, blood pressure, blood glucose, blood count, cholesterol total, HDL, LDL, and triglycerides.

Selection of Control Subjects

Control subjects aged 25-65 years were identified from community as healthy if their venous blood glucose values were <6.1 mmol/L and if they had never received any diabetic medication. They were 344 healthy subjects who visited the PHC Centers for any reason other than acute or chronic disease. They were chosen randomly from the daily appointment list. The health status was assessed by recording previous medical conditions, family history, physical examination, blood pressure, blood glucose, blood count, cholesterol total, HDL, LDL, and triglycerides.

The study was approved by the Research Ethics Committee of Hamad General Hospital and Hamad Medical Corporation. Informed consent was obtained from each person who agreed to participate in this study, which was carried out in accord with the Helsinki Declaration. The survey was based on standardized interviews performed by trained health professionals and nurses. Patients were classified as physically inactive if they reported not participating in physical activities such as cycling or walking for at least 30 min/day.

Height and weight were measured using standardized methods; the participants wore light clothes and no shoes for this part of the examination. The BMI was calculated as weight in kilograms (with 1 kg subtracted to allow for clothing) divided by height in meters squared. Subjects were classified into three categories: acceptable weight, BMI<25; overweight, BMI 25-30; and obese, BMI>30 (8).

Blood pressure measurement was carried out by trained practical nurses according to World Health Organization (WHO) standardized criteria (18). The mean value obtained from the three readings was used in the analysis. Hypertension was defined according to WHO criteria as systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg and/or the use of antihypertensive medication (18). Mean blood pressure was defined as 1/3 systolic pressure + 2/3 diastolic pressure. The pulse pressure was calculated as the difference between systolic and diastolic pressures. The fasting glucose test was performed according to the WHO recommendations (1). Plasma concentrations of glucose, insulin, triglycerides, total cholesterol, and HDL-cholesterol were determined in fasting blood samples (1).

Clinical Investigation

Samples for insulin were centrifuged and the serum was stored at -20 °C until assay. Serum insulin concentration were determined by a solid-phase ^{125}I radio-immunoassay kit (DPC, Los Angeles, CA, USA). The intra- and interassay coefficients of variation were 5% and 10%, respectively. Serum glucose was determined by the glucose dehydrogenase method (Dimension clinical chemistry system, Dade International Inc., Deerfield, IL, USA). Total cholesterol and triglycerides were measured using enzymatic techniques on a Technicon Analyzer (Technicon Instruments, New York, NY, USA). Measurement of HDL-cholesterol was performed using the same technique following heparin-manganese precipitation of VLDL- and LDL-cholesterol. The level of LDL- cholesterol was calculated using the Friedewald formula (19).

Statistical Analysis

Student *t* test was used to test the significance of differences between mean values of two continuous variables. Chi-square analysis was performed to test the differences in proportions of categorical variables between two or more groups. In 2×2 tables, the Fisher exact test (two-tailed) replaced the χ^2 test if the assumptions underlying χ^2 were violated, namely in case of small sample size or when the expected frequency was less than 5 in any of the cells. Odds Ratio (OR) and their 95% confidence intervals (CI) was calculated by the Mantel-Haenszel test. Multivariate logistic regression analysis was used to predict risk factors for di-

Table 1. Socio-demographic data of diabetic cases (n=338) and non diabetic controls (n=338)*

	No. (%) of subjects				
Variable	total	cases	controls	OR (95% CI)	*P*
Age group:					
<35	93 (24.0)	35 (17.1)	58 (31.7)	1.00	
35-50	136 (35.1)	69 (33.7)	67 (36.6)	1.71 (0.96-3.03)	0.051
>50	159 (41.0)	101 (49.3)	58 (31.7)	2.89 (1.64-5.08)	<0.001
Gender:					
female	376 (55.6)	192 (56.8)	184 (54.4)	1.00	
male	300 (44.4)	146 (43.2)	154 (45.6)	0.91(0.66-1.25)	0.536
Current marital status:					
single	131 (19.4)	58 (17.2)	73 (21.6)	1.00	
married	545 (80.6)	280 (82.8)	265 (78.4)	1.33 (0.89-1.99)	0.145
Education level:					
university	122 (18.0)	47 (13.9)	75 (22.2)	1.00	
secondary	190 (28.1)	75 (22.2)	115 (34.0)	1.04 (0.64-1.70)	0.867
primary	164 (24.3)	95 (28.1)	69 (20.4)	2.20 (1.32-3.65)	0.001
illiterate	200 (29.6)	121 (35.8)	79 (23.4)	2.44 (1.5-3.99)	<0.001
Income level:					
<5,000 QAR	250 (37.0)	135 (39.9)	115 (34.0)	1.00	
>5,000 QAR	426 (63.0)	203 (60.1)	223 (66.0)	0.78 (0.56-1.07)	0.111
No. of children:					
none	72 (10.7)	21 (6.2)	51 (15.1)	1.00	
≤5	313 (46.3)	155 (45.9)	158 (46.7)	2.38 (1.32-4.31)	0.002
>5	291 (43.0)	162 (47.9)	129 (38.2)	3.05 (1.69-5.54)	<0.001
Type of residence:					
villa	229 (33.9)	104 (30.8)	125 (37.0)	1.00	
shabia (mud house)	399 (59.0)	212 (62.7)	187 (55.3)	1.36 (0.97-1.91)	0.062
apartment	48 (7.1)	22 (6.5)	26 (7.7)	1.02 (0.52-1.98)	0.958
No. of rooms:					
≤5	385 (57.0)	206 (60.9)	179 (53.0)	1.00	
>5	291 (43.0)	132 (39.1)	159 (47.0)	0.72 (0.53-0.99)	0.036
No. of people living at home:					
≤5	162 (24.0)	66 (19.5)	96 (28.4)	1.00	
>5	514 (76.0)	272 (80.5)	242 (71.6)	1.63 (1.13-2.38)	0.007

*Abbreviations: OR – odds ratio; CI – confidence interval; QAR – Qatar Riyals, 1US$=3.65QAR.

abetes. The level $P \leq 0.05$ was considered as the cut-off value for significance.

Results

The mean ± standard deviation age for cases versus controls was 45.5 ± 8.9 vs 42.4 ± 8.0 years, $P < 0.001$ (Student *t* test).

Significantly more diabetics had low educational level (35.8% vs 23.4%, $P < 0.001$), and had more than 5 children (47.9% vs 38.2%, $P < 0.001$; Table 1). Significantly less diabetic subjects lived in houses with more than 5 rooms (39.1% vs 47.0%, $P = 0.036$) in households of more than five members (80.5% vs 71.6%, $P = 0.007$; Table 1).

The basic lifestyle habits, genetic, and family history among diabetic and non-diabetic cases are shown in Table 2. The diabetes was significantly more frequent among the consanguineous group (OR = 1.47, 95 % confidence interval (CI) = 1.07-2.03 and $P = 0.013$). Furthermore, among first degree consanguinity the chances of diabetes were even higher (OR = 1.59, 95% CI = 1.11-2.29, $P = 0.008$). Obesity was more common among diabetic patients 53.8% vs 41.1% (OR = 2.48, 95% CI = 1.61-3.84, $P < 0.001$). Consumption of salty food, vegetables, and red meat was similar in the two groups. Consumption of fruit was higher ($P = 0.011$), whereas consumption of fish/chicken was significantly lower in diabetic subjects ($P < 0.001$), since they are more aware of

Table 2. Life style, genetic, and family history of diabetic cases (n=338) and non diabetic controls (n=338)*

Variable	No. (%) of subjects: all	cases	controls	OR (95% CI)	*P*
Consanguinity:					
no	386 (57.1)	177 (52.4)	209 (61.8)	1.00	
yes	290 (42.9)	161 (47.6)	129 (38.2)	1.47 (1.07-2.03)	0.013
Degree of consanguinity:					
none	386 (57.1)	177 (52.4)	209 (61.8)	1.00	
second degree	95 (14.1)	49 (14.5)	46 (13.6)	1.26 (0.78-2.02)	0.317
first degree	195 (28.8)	112 (33.1)	83 (24.6)	1.59 (1.11-2.29)	0.008
BMI group (kg/m^2):					
≤25 (normal)	139 (20.6)	48 (14.2)	91 (26.9)	1.00	
25-30 (overweight)	216 (32.0)	108 (32.0)	108 (32.0)	1.90 (1.19-3.02)	0.004
>30 (obese)	321 (47.5)	182 (53.8)	139 (41.1)	2.48 (1.61-3.84)	<0.001
Physical activity:					
yes	321 (47.5)	160 (47.3)	161 (47.6)	1.00	
no	355 (52.5)	178 (52.7)	177 (52.4)	1.01 (0.74-1.38)	0.938
Smoking status:					
non smoker	526 (77.8)	288 (85.2)	238 (70.4)	1.00	
past smoker	74 (10.9)	28 (8.3)	46 (13.6)	0.50(0.30-0.85)	0.006
smoker	76 (11.2)	22 (6.5)	54 (16.0)	0.34 (0.19-0.59)	<0.001
Type of regular food intake:					
Salty food:					
no	322 (47.6)	172 (50.9)	150 (44.4)	1.00	
yes	354 (52.4)	166 (49.1)	188 (55.6)	0.77 (0.56-1.05)	0.090
Vegetables:					
yes	416 (61.5)	218 (64.5)	198 (58.6)	1.00	
no	260 (38.5)	120 (35.5)	140 (41.4)	0.78 (0.56-1.07)	0.114
Fruit:					
yes	371 (54.9)	202 (59.8)	169 (50.0)	1.00	
no	305 (45.1)	136 (40.2)	169 (50.0)	0.67 (0.49-0.92)	0.011
Red meat:					
no	391 (57.8)	195 (57.7)	196 (58.0)	1.00	
yes	285 (42.2)	143 (42.3)	142 (42.0)	1.00 (0.73-1.37)	0.990
Fish/chicken:					
no	239 (35.4)	149 (44.1)	90 (26.6)	1.00	
yes	437 (64.6)	189 (55.9)	248 (73.4)	0.46 (0.33-0.64)	<0.001
Family history in first degree relatives:					
hypertension:					
no	355 (52.5)	186 (55.0)	169 (50.0)	1.00	
yes	321 (47.5)	152 (45.0)	169 (50.0)	0.82 (0.60-1.12)	0.190
heart attack:					
no	515 (76.2)	251 (74.3)	264 (78.1)	1.00	
yes	161 (23.8)	87 (25.7)	74 (21.9)	1.24 (0.85-1.79)	0.241
diabetes mellitus:					
no	316 (46.7)	128 (37.9)	188 (55.6)	1.00	
yes	360 (53.3)	210 (62.1)	150 (44.4)	2.06 (1.49-2.83)	<0.001

*Abbreviations: BMI – body mass index; OR – odds ratio; CI – confidence interval.

Table 3. Baseline physical and metabolic characteristics (mean± standard deviation) in cases (n=338) and controls (n=338)

Variable	Cases	Controls	P*
Body mass index, BMI (kg/m^2)	30.5±4.8	28.6±5.2	<0.001
Blood pressure (mmHg):			
systolic	132.0±15.8	128.9±16.8	0.023
diastolic	82.2±9.2	81.0±9.6	0.098
mean	98.8±9.8	96.9±10.7	0.035
Pulse pressure (mmHg)	49.8±13.9	47.9±13.4	0.071
Cholesterol (mmol/L):			
total	5.4±1.1	4.6±1.0	<0.001
HDL	1.4±0.3	1.0±0.3	<0.001
LDL	3.7±0.9	3.2±0.5	<0.001
triglyceride	1.8±1.0	1.1±0.7	0.050

*Student *t* test.

Table 4. Multivariate logistic regression analysis for diabetes as dependent variable and lifestyle and genetic factors as independent variables*

Independent variables	OR (95% CI)	P
Smoking	2.42 (1.66-3.54)	<0.001
Degree of consanguinity	1.38 (1.13-1.69)	0.002
Body mass index, BMI (kg/m^2)	1.41 (1.12-1.76)	0.003
Level of education	1.23 (1.04-1.45)	0.017
Number of children	1.34 (1.02-1.77)	0.037
Systolic blood pressure	1.01 (1.00-1.02)	0.044

*Abbreviations: OR – odds ratio; CI – confidence interval.

their dieting habits. Self reported family history of diabetes in first-degree relatives was higher in diabetic than non-diabetic subjects and showed a highly significant difference ($P<0.001$).

Table 3 shows the baseline physical and metabolic characteristics of case and control subjects. The mean BMI and systolic blood pressure were significantly higher in diabetes patients than in control subjects. Total cholesterol, HDL-cholesterol, and triglyceride levels were higher in diabetes patients.

A stepwise logistic regression analysis was used to adjust for potential confounders and to order the importance of risk factors for diabetes (Table 4). The logistic regression model was adjusted for age and gender. Smoking ($P<0.001$), consanguinity ($P=0.002$), body mass index ($P=0.003$), level of education ($P=0.017$), number of children ($P=0.037$), and systolic blood pressure ($P=0.044$) were associated risk factors for diabetes.

Discussion

To the best of our knowledge, there are no population-based studies that have examined the prevalence of diabetes and associated risk factors in Qatar. In the present study, smoking, consanguineous marriages, number of people living in the same household, and number of children were positively associated with diabetes.

Many risk factors have been identified which influence the prevalence or incidence of diabetes. Factors of particular importance are family history of diabetes mellitus, age, overweight, increased abdominal fat, hypertension, lack of physical exercise, and ethnic background (11).

In our study, low educational level, smoking, obesity, and systolic blood pressure were associated risk factors. This is consistent with previous studies (3-5,8,17). One study reported relation of central obesity and insulin resistance with high diabetes prevalence and cardiovascular risk in South Asians (17). The high prevalence of diabetes in the Qatari population appears to be related to the interaction of environmental factors, such as obesity, with a diabetic genotype. The results confirm the possible detrimental effects of developing society on native populations. These findings are consistent with previous reports showing an association between diabetics' socioeconomic status, life-style-habits, obesity, and cardiovascular risk factors (3-8,17,20). In Japan, type 2 diabetes is an increasingly important problem as a life-style related disease, as the total diabetic population is estimated at approximately 7 million (21).

In the present study, most patients with type 2 diabetes mellitus were found to be obese. This complements other recent studies (4,5,8,11, 17,20). The association between type 2 diabetes mellitus and obesity is probably the result of multiple mechanisms, including rises in plasma free fatty acids and tumor necrosis factor alpha released from "full" adipocytes (11). More recently, it has been shown that in the Indian population, general and central obesity were associated with a family history of diabetes (20).

A family history of diabetes may increase the risk of hypertension and hyperlipidemia indirectly through its connection to BMI (8-10). Furthermore, lack of physical exercise is also associated with diabetes mellitus, which led to the finding that exercise enhances the action of insulin, although the present study did not confirm it. Glucose tolerance test data on 794 first-degree relatives of diabetics in pedigrees ascertained through non-insulin dependent diabetes mellitus were used to identify risk factors for diabetes in southeastern Michigan (20). In the Michigan study, the general risk factors, age and obesity, were important in predicting diabetes at the initial visit, although the predicted risk curves were very different for men and women. Our study in Qatar showed that diabetes was more common among first degree relatives in addition to obesity and environmental factors influencing glucose tolerance among siblings.

In summary, the present study was directed at determining the effect of consanguineous marriages, obesity, and environmental risk factors of diabetes in the adult population of Qatar. The characterization of these factors will contribute to defining more effective and specific strategies to screen for and control diabetes mellitus in this developing country. From a life-style modification perspective, the importance of body weight control by diet and exercise as well as refraining from excessive smoking and avoiding consanguineous marriages should be emphasized.

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References

1 Alberti KG, Zimmet PZ. 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. 1998;15:539-53.

2 Zimmet PZ. The burden of type 2 diabetes: are we doing enough? Diabetes Metab. 2003;29:9-18.

3 Knowler WC, Pettitt DJ, Saad MF, Bennett PH. Diabetes mellitus in the Pima Indians: incidence, risk factors and pathogenesis. Diabetes Metab Rev. 1990;6:1-27.

4 Mayer-Davis EJ, Costacou T. Obesity and sedentary lifestyle: modifiable risk factors for prevention of type 2 diabetes. Curr Diab Rep. 2001;1:170-6.

5 Lieberman LS. Dietary, evolutionary, and modernizing influences on the prevalence of type 2 diabetes. Annu Rev Nutr. 2003;23:345-77.

6 Quinn L. Behavior and biology: the prevention of type 2 diabetes. J Cardiovasc Nurs. 200;18:62-8.

7 Deloumeaux J, Ninin E, Foucan L. Anthropometric parameters and type 2 diabetes: a case-control study in a Guadeloupean population. Diabetes Metab. 2004; 30:75-80.

8 Bener A, Al-Suwaidi J, Al-Jaber K, Al-Marri S, Elbagi IE. Epidemiology of hypertension and its associated risk factors in the Qatari population. J Hum Hypertens. 2004;18:529-30.

9 Hamman RF. Genetic and environmental determinants of non-insulin-dependent diabetes mellitus (NIDDM). Diabetes Metab Rev. 1992;8:287-338.

10 Ramachandran A, Snehalatha C, Satyavani K, Sivasankari S, Vijay V. Cosegregation of obesity with familial aggregation of type 2 diabetes mellitus. Diabetes Obes Metab. 2000;2:149-54.

11 van Tilburg J, van Haeften TW, Pearson P, Wijmenga C. Defining the genetic contribution of type 2 diabetes mellitus. J Med Genet. 2001;38:569-78.

12 Poulton J, Luan J, Macaulay V, Hennings S, Mitchell J, Wareham NJ. Type 2 diabetes is associated with a common mitochondrial variant: evidence from a population-based case-control study. Hum Mol Genet. 2002;11:1581-3.

13 DeFronzo RA. Insulin resistance: a multifaceted syndrome responsible for NIDDM, obesity, hypertension, dyslipidaemia and atherosclerosis. Neth J Med. 1997; 50:191-7.

14 Lillioja S, Mott DM, Howard BV, Bennett PH, Yki-Jarvinen H, Freymond D, et al. Impaired glucose tolerance as a disorder of insulin action. Longitudinal and cross-sectional studies in Pima Indians. N Engl J Med. 1988;318:1217-25.

15 McKeigue PM, Shah B, Marmot MG. Relation of central obesity and insulin resistance with high diabetes prevalence and cardiovascular risk in South Asians. Lancet. 1991;337:382-6.

16 Ferrannini E, Buzzigoli G, Bonadonna R, Giorico MA, Oleggini M, Graziadei L, et al. Insulin resistance in essential hypertension. N Engl J Med. 1987;317:350-7.

17 Musaiger AO, Al-Mannai MA. Social and lifestyle factors associated with diabetes in the adult Bahraini population. J Biosoc Sci. 2002;34:277-81.

18 1999 World Health Organization – International Society of Hypertension Guidelines for the Management of Hypertension. Guidelines Subcommittee. J Hypertens. 1999;17:151-83.

19 Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin Chem. 1972;18:499-502.

20 Habib SS, Aslam M. Lipids and lipoprotein concentrations in Pakistani patients with type 2 diabetes mellitus. Diabetes Obes Metab. 2004;6:338-43.

21 Matsuoka K. Genetic and environmental interaction in Japanese type 2 diabetics. Diabetes Res Clin Pract. 2000;50 Suppl 2:S17-22.

22 Beaty TH, Neel JV, Fajans SS. Identifying risk factors for diabetes in first degree relatives of non-insulin dependent diabetic patients. Am J Epidemiol. 1982;115:380-97.

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