

Prevalence and Determinants of Glucose Intolerance in a Dutch Caucasian Population

The Hoorn Study

JOHANNA M. MOOY, MD
PETER A. GROOTENHUIS, MD, PHD
HENDRIK DE VRIES, MD, PHD
HANS A. VALKENBURG, MD, PHD

LEX M. BOUTER, PHD
PIETER J. KOSTENSE, PHD
ROBERT J. HEINE, MD, PHD

OBJECTIVE — To study the prevalence and determinants of glucose intolerance in a general Caucasian population.

RESEARCH DESIGN AND METHODS — A random sample of 50- to 74-year-old Caucasians ($n = 2,484$) underwent oral glucose tolerance tests. Multiple regression analyses were performed to study the association of 2-h postload plasma glucose values with potential determinants.

RESULTS — Prevalence of known and newly detected diabetes and impaired glucose tolerance was 3.6, 4.8, and 10.3%, respectively. In women, but not in men, the association of body mass index with 2-h glucose was fully accounted for by the waist-to-hip ratio. Maternal history of diabetes was twice as prevalent as paternal history, but paternal history only was associated with 2-h glucose. In addition, paternal history was a stronger determinant in men than in women. An independent positive association with 2-h plasma glucose was found for alcohol use of >30 g/day in women and for intake of total protein, animal protein, and polyunsaturated fatty acids in men. An independent inverse association with 2-h plasma glucose was demonstrated for height (both sexes), alcohol use of ≤ 30 g/day (both sexes), energy intake (in men), and, unexpectedly, current smoking (in men).

CONCLUSIONS — The prevalence of diabetes in elderly Caucasians was 8.3%. In men, dietary habits may unfavorably influence glucose tolerance independent of obesity.

From the Institute for Research in Extramural Medicine (J.M.M., P.A.G., H.D.V., H.A.V., L.M.B., R.J.H.), the Department of General Practice and Nursing Home Medicine (H.D.V.), the Department of Epidemiology and Biostatistics (L.M.B., P.J.K.), and the Department of Internal Medicine (R.J.H.), Vrije Universiteit, Amsterdam, the Netherlands.

Address correspondence and reprint request to Johanna M. Mooy, MD, Institute for Research in Extramural Medicine, Vrije Universiteit, Van der Boechorststraat 7, 1081 BT Amsterdam, the Netherlands. E-mail: jm.mooy.emgo@med.vu.nl.

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BMI, body mass index; WHR, waist-to-hip ratio; 2hPG, 2-h plasma glucose.

In this study, we describe the prevalence of glucose intolerance and the association of 2-h plasma glucose (2hPG) concentration with potential risk factors in an elderly Caucasian population.

RESEARCH DESIGN AND METHODS

A random sample of all residents aged 50–74 years from the Dutch city of Hoorn (57,000 inhabitants) was invited to participate in a cross-sectional survey (1989–1992) on glucose tolerance. Caucasian ethnicity was defined as having at least three grandparents from European or Mediterranean countries. All participants not treated with oral hypoglycemic agents or insulin had a 75-g oral glucose tolerance test (1). Verified known diabetes was defined by 1) use of insulin or oral hypoglycemic agents or 2) when diet only had been prescribed, a fasting plasma glucose and/or 2hPG value meeting the World Health Organization criteria for diabetes (1). Plasma glucose levels and anthropometric measures were determined according to standardized procedures (2,3). Family history of diabetes was defined as positive if any of the subject's grandparents, parents, brothers, sisters, or children had a history of diabetes. Physical activity was measured by asking nine equally weighted yes-or-no questions about regularly performing the following activities: playing sports, bicycling, gardening, walking, doing odd jobs, climbing the staircase at home, doing household activities, doing daily food shopping, and working, whether paid or unpaid (4). Dietary habits, including alcohol intake, were measured by a self-administered validated semiquantitative food-frequency questionnaire (5).

The association of 2hPG values with potential determinants was investigated by regression analyses. We first studied each nutrient variable separately: Only those nutrients were entered into the final model (Table 3), which for either men or women had 1) a significant ($P < 0.05$) "crude" (adjusted for energy intake

Table 1—Prevalence of diabetes and impaired glucose tolerance in a Dutch Caucasian population aged 50–74 years stratified for age and sex

Stratum	n	Known diabetes	New diabetes	IGT
Men				
50–54	283	1.8	1.4	5.7
55–59	263	2.7	5.7	6.8
60–64	216	3.7	4.2	11.1
65–69	201	4.0	5.5	9.0
70–74	178	3.9	9.0	16.3
All men	1,141	3.1 (2.1–4.1)	4.8 (3.6–6.0)	9.2 (7.5–10.9)
Women				
50–54	294	1.0	1.0	5.9
55–59	282	1.8	2.1	7.1
60–64	263	3.8	6.5	10.6
65–69	256	6.3	5.5	16.4
70–74	232	8.2	9.9	18.1
All women	1,327	4.0 (2.9–5.1)	4.7 (3.6–5.8)	11.2 (9.6–12.8)
All	2,468	3.6 (2.9–4.3)	4.8 (4.0–5.6)	10.3 (9.1–11.5)

Data are % (95% confidence interval) except where indicated. IGT, impaired glucose tolerance. Prevalence of diabetes is based on fasting and 2-h plasma glucose (1). In four subjects with known diabetes (0.2%), it was diagnosed before the age of 40 years.

Table 2—Age-adjusted subjects' characteristics stratified by sex and glucose tolerance

	Men			Women		
	NGT	IGT	New diabetes	NGT	IGT	New diabetes
n	878	99	52	1,027	142	58
Age in years	61 ± 7	64 ± 7	64 ± 7	61 ± 7	65 ± 7	67 ± 6
Fasting plasma glucose (mmol/l)	5.5 ± 0.6	6.0 ± 0.6	8.0 ± 2.5	5.3 ± 0.5	5.9 ± 0.7	8.2 ± 3.3
2-h plasma glucose (mmol/l)	5.1 ± 1.3	8.9 ± 1.0	14.5 ± 4.2	5.4 ± 1.2	9.0 ± 0.9	14.9 ± 6.0
Family history of diabetes (% yes)	23	29	43*	27	36	35
BMI (kg/m ²)	26 ± 3	28 ± 3*	28 ± 3*	27 ± 4	28 ± 4*	29 ± 5*
WHR	0.94 ± 0.06	0.98 ± 0.06*	1.00 ± 0.07*	0.84 ± 0.07	0.87 ± 0.07*	0.91 ± 0.08*
Height (cm)	175 ± 7	174 ± 6	174 ± 6	163 ± 6	162 ± 6	161 ± 7
Physical activities (n)	5.7 ± 1.6	5.3 ± 1.8	5.5 ± 1.6	5.4 ± 1.5	5.1 ± 1.5*	5.2 ± 1.7
Alcohol use (% distribution)	16;72;12	24;61;15	17;63;20	41;56;3	43;50;7	52;42;6
Current smoking (% yes)	37	27	30	28	28	32
Daily nutrient intake						
Energy (kcal × 1,000)	2.33 ± 0.59	2.17 ± 0.58	2.19 ± 0.68	1.84 ± 0.48	1.79 ± 0.43	1.84 ± 0.47
Protein total (E%)	14 ± 2	15 ± 3*	15 ± 4*	15 ± 3	15 ± 3	15 ± 3
Vegetable	4 ± 1	4 ± 1	4 ± 1	4 ± 1	4 ± 1	4 ± 1
Animal	9 ± 2	10 ± 3*	11 ± 4*	11 ± 3	11 ± 3	11 ± 3
Fat total (E%)	41 ± 6	41 ± 6	39 ± 6	41 ± 6	41 ± 7	42 ± 6
Saturated	17 ± 3	17 ± 3	16 ± 3	17 ± 3	18 ± 4	18 ± 4
Monounsaturated	15 ± 3	15 ± 3	15 ± 3	15 ± 3	15 ± 3	15 ± 3
Polyunsaturated	8 ± 3	9 ± 3	8 ± 3	8 ± 3	8 ± 3	8 ± 3
Carbohydrate total (E%)	41 ± 6	40 ± 7	40 ± 8	42 ± 6	42 ± 7	40 ± 7
Mono- and disaccharides	20 ± 6	19 ± 6	20 ± 7	21 ± 6	20 ± 6	20 ± 7
Polysaccharides	21 ± 4	21 ± 5	20 ± 4	21 ± 4	21 ± 5	20 ± 4
Alcohol (E%)	4 ± 4	4 ± 5	6 ± 8*	2 ± 3	2 ± 4	2 ± 4
Dietary cholesterol (g/day)	3.0 ± 1.1	2.9 ± 1.0	3.0 ± 1.4	2.6 ± 1.0	2.5 ± 1.0	2.7 ± 1.0
Dietary fiber (g/day)	29 ± 9	26 ± 7*	26 ± 8	26 ± 7	26 ± 7	25 ± 8

Data are means ± SD or %, adjusted for age by analysis of covariance or direct standardization, respectively; standard: present study population. Alcohol use is expressed as percentage distribution over three categories: 1) none, 2) moderate (1–30 g/day), and 3) heavy alcohol use (>30 g/day). For men, n = 1,029; for women, n = 1,227. NGT, normal glucose tolerance; IGT, impaired glucose tolerance; E%, energy percentage. *P < 0.01 for age-adjusted difference with NGT (logistic regression analysis).

Table 3—Percentage difference in 2-h plasma glucose associated with the indicated difference in potential determinants stratified by sex

Differences in determinant	% Difference in 2-h plasma glucose				
	Men		Women		
	Crude	Adjusted	Crude	Adjusted	
Age (years)	+10	+12‡	+8‡	+15‡	+9‡
Family history of diabetes	no to yes	+9‡	+8‡	+7‡	+6‡
BMI (kg/m ²)	+2 SD	+23‡	+10‡	+16‡	+2
WHR	+2 SD	+26‡	+15‡	+26‡	+20‡
Height (cm)	+2 SD	-12‡	-6*	-11‡	-5*
Physical activity	below to above median	-8*	-4	-14‡	-4
Moderate alcohol use	none to use of ≤30 g/day	-9‡	-5*	-10‡	-4*
Heavy alcohol use	none to use of >30 g/day	0	0	+10‡	+11‡
Current smoking	no to yes	-10‡	-6*	-6‡	-4
Relevant daily nutrient intake					
Energy (kcal)	+2 SD	-13‡	-6‡	-5*	-1
Protein total (E%)	+2 SD	+8‡	+6‡	0	+1
Fatty acids polyunsaturated (E%)	+2 SD	+7‡	+7‡	+1	+1

For men, $n = 1,029$; for women, $n = 1,227$. E%, energy percentage. The crude associations of the nutrients have been corrected for energy intake only. Adjusted difference is adjusted for all other determinants in this model. Relevant SD values for men and women, respectively: BMI: 3, 4; WHR: 0.06, 0.07; height: 7, 6; energy: 597, 473; protein total: 3, 3; fatty acids polyunsaturated: 3, 3. * $P < 0.05$, † $P < 0.01$, ‡ $P < 0.001$.

sion analysis. Regression coefficients have been retransformed to percentage differences in 2hPG values associated with specified differences in the independent variable.

RESULTS— There were 2,540 participants out of 3,553 eligible subjects (71%). From 93% of the 1,013 nonparticipants, we obtained relevant information indicating that there was no substantial participation bias (2). We excluded 56 non-Caucasians, and samples were missing for 16 subjects. Prevalence of impaired glucose tolerance and diabetes is shown in Table 1. Complete data on all determinants were available from 2,256 subjects without a history of diabetes, described in Table 2.

Prevalence of total diabetes was 8.3% (95% confidence interval: 7.2–9.4). Table 3 shows the association of all relevant potential determinants with 2hPG. In both sexes, the full model explained 18% of the variance (R^2) of the 2hPG values. Substituting animal protein for total protein resulted in the same significant adjusted association with 2hPG. In both

sexes, the polyunsaturated fatty acids consisted mainly (84%) of ω -6 fatty acids from linoleic acid. We compared an undesirable risk factor profile with a desirable risk factor profile, contrasting only the modifiable risk factors. For example, considering two men both aged 60 years, 1.75 m tall, and with a positive family history of diabetes, but differing with respect to BMI, WHR, protein and polyunsaturated fatty acid intake (1 SD above versus 1 SD below the mean value for men), physical activity (below versus above the median value for men), and moderate alcohol use (no versus yes), the predicted difference in 2hPG is 2.6 mmol/l.

In Table 4, the association of family history with 2hPG is further analyzed for paternal and maternal history of diabetes separately. In both sexes, maternal history is twice as prevalent as paternal history of diabetes. Considering new and known diabetic subjects diagnosed after the age of 40 years, together ($n = 202$) 59 and 29 individuals had a maternal or a paternal history, respectively.

CONCLUSIONS— The Dutch prevalence of known and newly detected diabetes was approximately the same as in other Caucasian populations. A stronger association of BMI with glucose tolerance

Table 4—Adjusted percentage difference in 2-h plasma glucose associated with having (no to yes) a paternal or maternal family history of diabetes stratified by sex

	Paternal history		Maternal history	
	Men	Women	Men	Women
n of positive history	54	52	98	132
% difference (P)	+20 (<0.001)	+8 (0.07)	+4 (0.25)	+2 (0.43)

The percentage difference is adjusted for all determinants listed in Table 3 (except for family history of diabetes). For men, $n = 1,029$; for women, $n = 1,227$.

in men than in women was also reported in the Mauritius Study (6) and is difficult to explain. Our data confirmed earlier reports on a high prevalence of maternal history of diabetes (7). Relatively new is the finding of a strong association between paternal history of diabetes and glucose tolerance in men. It is unclear what kind of reporting bias could have contributed to these findings. Remarkably, we found that animal protein intake, instead of saturated fat intake, was associated with glucose intolerance. Our data are consistent with the hypothesis that polyunsaturated fatty acids of different classes may affect glucose tolerance in opposite directions (8,9). The precise role of these dietary factors will have to be elucidated in prospective studies.

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