The Relationship of Fasting Plasma Glucose Values and Other Variables to 2-h Postload Plasma Glucose in Japanese Subjects

YUKIHIRO BANDO, PHD
YASUYUKI USHIOGI, PHD
KAZUHIRO OKAFUJI, MD
DAISYU TOYA, MD
NOBUYOSHI TANAKA, MD
MASAKIYO FUJISAWA, MD

OBJECTIVE — To investigate the relationship between fasting plasma glucose (FPG) values and other variables (e.g., age, sex, and BMI) to 2-h post–75-g oral glucose load glycemia (PG) in Japanese subjects.

RESEARCH DESIGN AND METHODS — Subjects included 13,694 Japanese subjects between 20 and 83 years of age (10,677 men and 3,017 women) who were undergoing a 75-g oral glucose tolerance test (OGTT) during a health screening performed at our hospital. The influences of age for 2-h PG at a fixed fasting plasma glucose (FPG) level of 126 mg/dl were analyzed. Multiple linear regression analysis was performed using a model in which the dependent variable was 2-h PG using the following explanatory variables: FPG, age, sex, BMI, blood pressure, plasma cholesterol, and triglyceride (TG) levels.

RESULTS — The 2-h PG at a fixed FPG of 126 mg/dl increased by 0.94 mg/dl per year in patients aged between 30 and 78 years ($r = 0.68$, $P < 0.0001$). In multiple regression, five explanatory variables (FPG, age, BMI, plasma TG levels, and systolic blood pressure levels) were all positively associated with 2-h PG. The percentages of patients with 2-h diabetes (isolated postchallenge hyperglycemia [IPH]) versus fasting plus 2-h diabetes by the World Health Organization criteria significantly ($P = 0.005$) increased as the patients' decades increased, whereas the impact of BMI on the percentages was significant only in young patients ($P = 0.001$).

CONCLUSIONS — Aging was found to be the second best predictor of 2-h PG on multiple regression. Therefore, OGTT should be performed especially in elderly patients because they show IPH more frequently.

Diabetes Care 24:1156–1160, 2001

The diagnostic criteria for diabetes and glucose intolerance have been reviewed by the American Diabetes Association (ADA) (1) and the World Health Organization (WHO) (2). The ADA proposed that diabetes should be defined by a preload fasting plasma glucose (FPG) level of 126 mg/dl (7.0 mmol/l) alone and did not recommend the use of the oral glucose tolerance test (OGTT). On the other hand, the WHO recently stated that, ideally, a full OGTT should be performed, although it also recommended the same FPG values as those proposed by the ADA as well as a 2-h post–75-g oral glucose load glycemia (PG) of 200 mg/dl (11.1 mmol/l).

These revised guidelines uniformly estimate that an FPG of 126 mg/dl would be almost equivalent to a 2-h PG of 200 mg/dl, based on a large volume of epidemiological data using receiver-operating characteristics curve analysis (3) of Pima Indians (4), Egyptians (5), subjects from the Pacific region (6), and the third National Health and Nutrition Examination Survey.

However, if the relationship between FPG and 2-h PG alters under the influence of other variables, this equality may vary in individuals with different levels of these variables. It has previously been reported that isolated postchallenge hyperglycemia (IPH) (2-h PG ≥200 mg/dl and FPG <126 mg/dl) becomes more common in elderly subjects (7–10). Both previous (11,12) and recent reports (13,14) also suggested a relatively higher prevalence of IPH in women than in men.

Nevertheless, previous reports did not elucidate to what degree variables other than FPG may independently contribute to the 2-h PG on a statistical basis. Therefore, we performed a cross-sectional study to investigate the relationship between FPG and other variables (e.g., age, sex, and BMI) to the 2-h PG using a large series of Japanese subjects being health screened in Fukui-Saiseikai Hospital, Fukui, Japan.

RESEARCH DESIGN AND METHODS

— We reviewed data for 13,694 consecutive Japanese subjects (10,677 men and 3,017 women, aged 20–83 years [mean age at testing 51.4 years]) undergoing the 75-g OGTT for diagnosis of diabetes during a health screening performed at Fukui-ken Saiseikai Hospital, Fukui, from May 1994 to March 1999. None of the subjects had a history of diabetes or symptoms suggesting overt hyperglycemia, such as severe thirst or

From the Department of Internal Medicine, Fukui-ken Saiseikai Hospital, Fukui, Japan.
Address correspondence and reprint requests to Yukihiro Bando, PhD, Department of Internal Medicine, Fukui-ken Saiseikai Hospital, Funabashi 7-1, Wadanaka-machi, Fukui 918-8503, Japan. E-mail: bando@po.incl.ne.jp.
Received for publication 3 July 2000 and accepted in revised form 2 March 2001.
Abbreviations: ADA, American Diabetes Association; FPG, fasting plasma glucose; IFG, impaired fasting glucose; IGT, impaired glucose tolerance; IPH, isolated postchallenge hyperglycemia; OGTT, oral glucose tolerance test; PG, post–75-g oral glucose load glycemia; TG, triglyceride; WHO, World Health Organization.
A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Table 1—*Baseline characteristics of the subjects*

Characteristic	*n* (%)
Sex*	
Male	10,677 (78.0)
Female	3,017 (22.0)
Total	13,694
Age (years)†	
20–29	57 (0.4)
30–39	1225 (8.9)
40–49	4847 (35.4)
50–59	5200 (38.0)
60–69	2037 (14.9)
70–79	325 (2.3)
80+	13 (0.1)
BMI (kg/m^2)‡	
<18	291 (2.1)
18–<20	1200 (8.8)
20–<22	2683 (19.6)
22–<24	3766 (27.5)
24–<26	3423 (25.0)
26–<28	1482 (10.8)
28–<30	508 (3.7)
>30	341 (2.5)

*There were significant differences in the average age and BMI between the male and female groups (51.0 ± 8.9 vs. 52.1 ± 9.2 years, $P < 0.0001$, and 23.5 ± 3.8 vs. 22.7 ± 2.9 kg/m^2, $P < 0.0001$, respectively); †51.4 ± 11.3; ‡23.4 ± 2.75.

polyuria. Excluded were subjects who had fasting hyperglycemia of >200 mg/dl; who had a history of gastrectomy, liver injury, any malignancy, or any endocrinological disease; or who were regularly receiving any drugs, including antihypertensive agents, lipid-lowering agents, or steroids. All subjects were prescribed a standard diet composed of 57% carbohydrate, 25% fat, and 18% protein and were asked to fast from 10:00 P.M.; they then underwent a standard WHO OGTT (15) between 8:00 A.M. and 10:00 A.M. the next morning. This study was approved by the ethical committee of Fukui-ken Saiseikai Hospital.

Assay

FPG and 2-h PG were measured using the glucose oxidase method on a Hitachi 717 analyzer. The intra- and interassay coefficients of variation were 1.3 and 1.4%, respectively. Blood pressure was measured by a trained physician using a calibrated mercury sphygmomanometer on the right arm, with the subject in the supine position, on the second day of the health screening. Cholesterol and triglycerides (TGs) were measured enzymatically in serum using a kit (Sinotest, Tokyo, and Aswell, Osaka, respectively). The lipid estimations were performed using fasting samples. BMI was calculated as the weight (in kilograms) divided by the height squared (in meters).

Statistical analysis

Data are expressed as means ± SEM. Significance of differences in mean values was determined using a two-tailed unpaired *t* test. We estimated the correlations between FPG and 2-h PG using Pearson or Spearman correlation coefficients, as appropriate. Linear regression analysis was used to calculate regression equations between two variables. Multiple linear regression analyses were performed using a model in which the dependent variable was the 2-h PG, with

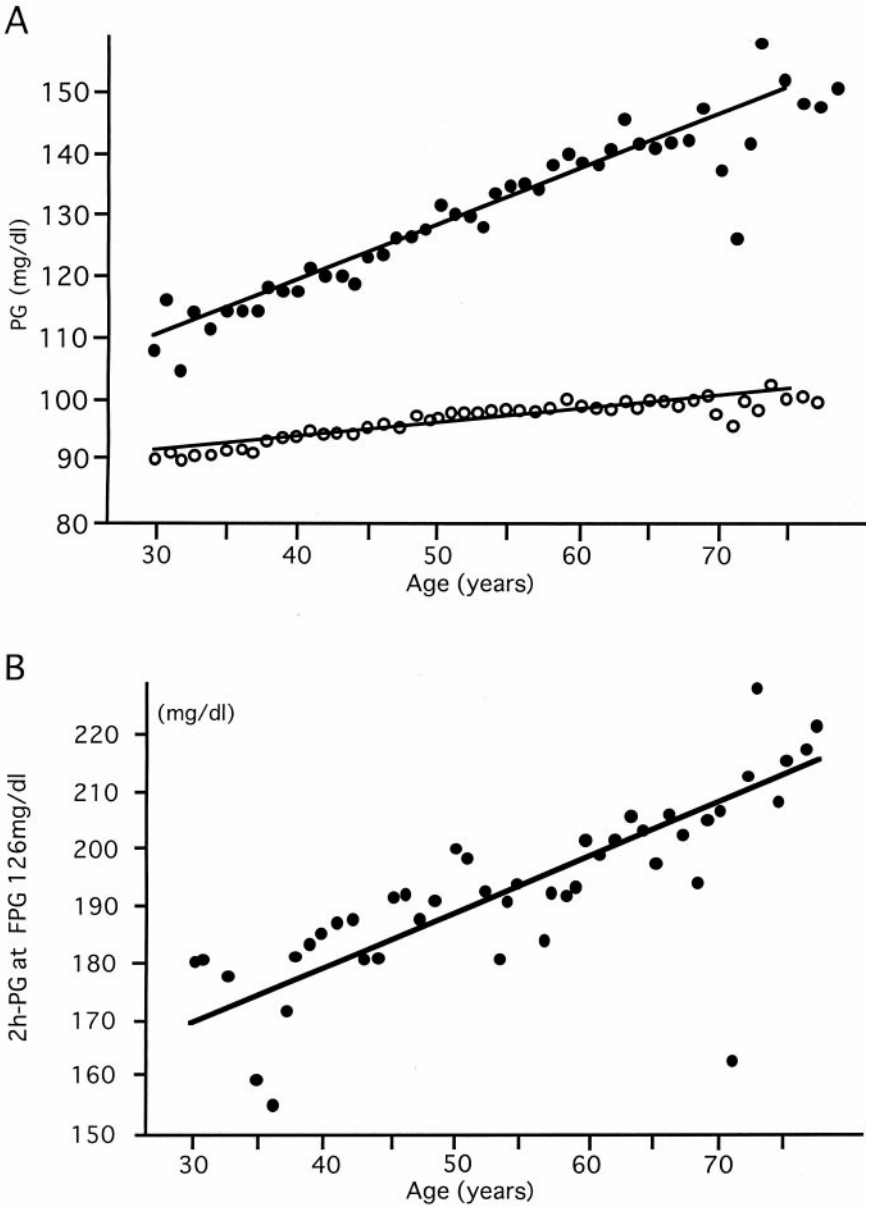

Figure 1—A: *The average FPGs and 2-h PGs with respect to age in years* (r = *0.89 and 0.94,* P < *0.0001, respectively*). ○, *Average FPGs;* ●, *average 2-h PGs. The regression equations for the average FPGs and 2-h PGs with respect to age were* y = *0.20*x + *85.8 and* y = *0.86*x + *84.7, respectively*. B: *The 2-h PG at FPG 126 mg/dl and the age in years between 30 and 78* (r = *0.67,* P < *0.0001). The regression equation calculated was* y = *0.94*x + *85.8. The 2-h PG at FPG 126 mg/dl was calculated from the regression equation of the FPGs and 2-h PGs taken from plots of yearly aged cohorts, all of which were significant (see text).*

the following explanatory variables: FPG, age, sex, BMI, systolic and diastolic blood pressures, serum cholesterol, and TG levels. All variables were entered into the analysis simultaneously.

Differences with probability values <0.05 were considered significant. The statistical software StatView version 5.0 (SAS Institute, Cary, NC) was used for the analyses.

RESULTS — The baseline characteristics for all subjects are shown in Table 1. The most prevalent patient decade was the fifties, whereas the twenties and eighties had very small sample sizes. Moreover, the most prevalent range of BMI was 22 to <24 kg/m^2, whereas values under 18 and over 28 had relatively small sample sizes. There were significant differences in average age and BMI between the male and female groups. In our study population, the overall prevalences of normal glucose tolerance, impaired fasting glucose (IFG)/impaired glucose tolerance (IGT), and diabetes were 71.1% (n = 9,736), 22.7% (n = 3,108), and 6.2% (n = 850), respectively, using the 1999 WHO criteria (2).

Scatterplots of FPG and 2-h PG during the 75-g OGTT in all subjects showed a significant positive correlation between both PGs, whereas the regression equation in which x and y represented FPG and 2-h PG, respectively ($y = 2.212x - 84.5$), indicated that the 2-h PG level corresponding to a FPG of 126 mg/dl was ~194 mg/dl. However, because the SD of 2-h PG in the regression equation was markedly large at 35.1 mg/dl, ~68% of subjects at an FPG of 126 mg/dl were distributed across a wide range between 158.9 and 229.1 mg/dl for the 2-h PG.

As shown in Fig. 1*A*, the average FPG and 2-h PG increased significantly with yearly aging, whereas the slope of the regression equation was significantly ($P < 0.001$) higher in the latter compared with the former (0.86 and 0.20, respectively). Then, we calculated the 2-h PG equivalent to an FPG of 126 mg/dl (i.e., 2-h PG at a fixed FPG of 126 mg/dl, abbreviated to "2-h PG at FPG 126 mg/dl" hereafter) using the regression equation between FPGs and 2-h PGs for each aged-based cohort, all of which were significant (n = 58–633, r = 0.28–0.89, $P < 0.05$–0.0001). As shown in Fig. 1*B*, the 2-h PG at FPG 126 mg/dl increased linearly with years of age between 30 and 78 years, whereas the slope of the regression equation was 0.94, implying that this value proportionally increased at 9.4 mg/dl per decade.

Table 2—*Results of multiple regression analysis with 2-h PG as the outcome variable

Variable†	Regression coefficient	SEM	Standardized regression coefficient	Percent contribution	*P*
FPG (mg/dl)	2.047	0.022	0.606	41.6	<0.0001
Age (years)	0.421	0.030	0.92	5.2	<0.0001
BMI (kg/m^2)	1.019	0.101	0.069	3.3	<0.0001
Systolic blood pressure (mmHg)	0.055	0.026	0.022	3.0	0.0315
Serum TG (mg/dl)	0.025	0.003	0.057	2.7	<0.0001

*r^2 = 0.434; †Other variables were examined but did not show significant associations with the 2-h PG variables, including sex (P = 0.72), diastolic blood pressure (P = 0.21), and total serum cholesterol level (P = 0.47).

Multiple linear regression analysis with 2-h PG

Multiple linear regression was used to determine variables contributing to the 2-h PG (Table 2). Sex did not contribute significantly (P = 0.4) when BMI was included in the analysis, which indicated that the correlation between 2-h PG and sex is dependent on BMI. As a result, five independent variables (FPG, age, BMI, serum TG levels, and systolic blood pressure levels) were all significantly associated with 2-h PG.

In particular, the regression procedure indicated FPG as the best predictor of 2-h PG, whereas the former could explain only 41.6% of the variance of the latter. Additionally, the second and third major predictors of 2-h PG were age and BMI, respectively. In the resulting regression equation [2-h PG (mg/dl) = (2.05 × FPG) + (0.42 × age) + (1.02 × BMI) + (0.025 × plasma TG level) + (0.055 × systolic blood pressure level) − 119.7], the coefficients for all variables were significant (P = 0.03 to <0.0001). All five of these variables, however, could explain only 43.4% of the total variance in the 2-h PG.

The percentages of patients with 2-h diabetes (IPH) versus fasting plus 2-h diabetes, stratified by age and BMI, are shown in Fig. 2. The percentages increased significantly (P = 0.005–0.05 on regression analysis) along with advancing of patients' decades, except in the subjects with a BMI of 26 to <28 and those with a BMI ≥30. However, the impact of BMI on the percentages was not significant except in the subjects aged 30–39 (P = 0.001 on regression analysis).

CONCLUSIONS — In several studies, FPG and 2-h PG during an OGTT

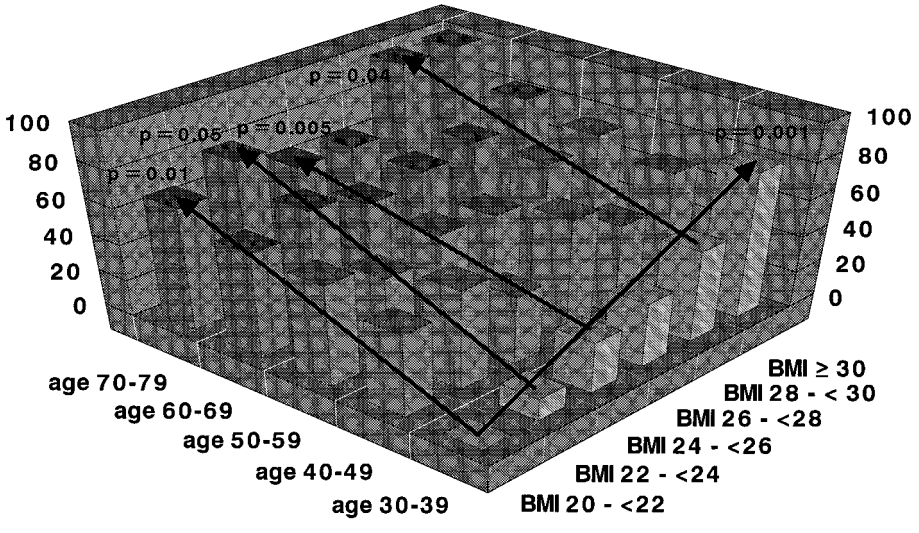

Figure 2—*The percentages of patients with 2-h diabetes (IPH) versus fasting plus 2-h diabetes, stratified by age and BMI.*

were strongly predictive diabetic complications and nearly equivalent in their predictive abilities (1,4,5).However, more recently, the effect of postload hyperglycemia in the pathogenesis of diabetic complications was gradually accumulated through in vivo and in vitro studies (16). That is, several large population-based prospective studies showed that 2-h PG, though not FPG, was a significant predictor of *1*) subsequent cardiovascular disease or mortality in the general population (17), *2*) IGT (18), and *3*) newly detected type 2 diabetes (19). Moreover, some recent studies (20–22) demonstrated that 2-h PG was a stronger determinant than FPG of carotid artery stenosis, a well known marker of systemic atherosclerosis. Furthermore, with regard to microangiopathy, a recent epidemiological study by Itoh et al. (23) using a large series of Japanese subjects receiving health screening demonstrated that 2-h PG compared with FPG was more highly associated with the incidence of retinopathy. On the other hand, in vitro evidence demonstrated that postprandial hyperglycemia plays an important role in the progression of atherosclerosis or microangiopathy via the generation of oxygen-derived free radicals, vasoconstriction, activation of coagulation, and the increase of intracellular adhesion molecule-1 plasma level (16) .

Thus, from a diagnostic standpoint, it is important to elucidate potential variables contributing to 2-h PG values other than FPG. In this context, the impairment of glucose tolerance with aging has been confirmed by numerous previous studies indicating that this decline in glucose tolerance, which begins in the third decade, continues throughout adulthood (11,24,25). These age-related changes particularly characterize the impaired response to glucose challenge rather than FPG, partly due to physical inactivity (26) and potentially associated with a decrease in muscle mass. In more recent estimations based on arterialized venous plasma, the age-related increase in glucose concentrations from 60 to 180 min after a 100-g oral glucose load averaged 13–14 mg/dl per decade (25). These reports agreed with our results, which showed a mean increase of 9.4 mg/dl per decade between the ages of 30 and 78 years ($r = 0.68$, $P < 0.0001$) in the values for 2-h PG at FPG 126 mg/dl. These observations suggest that the 1999 WHO criteria, using 2-h PG values, could be expected to give higher estimated prevalence of untreated diabetes in older subjects than the ADA fasting criteria, as supported by some recent reports (27,28).

Second, obesity is well known to be linked to hepatic and peripheral insulin resistance in healthy subjects and in patients with type 2 diabetes (29), partly via elevated serum free fatty acid (30) and tumor necrosis factor-α levels (31), which may induce inadequate suppression of postprandial hepatic glucose production and decreased hepatic and peripheral glucose uptake, and partly via inhibition of insulin receptors and postreceptor signal transductions (31). Obesity, therefore, and visceral obesity in particular (32), may individually accelerate postload hyperglycemia.

Although these lines of evidence suggest that variables other than FPG may contribute to postload glycemia, it is not clear to what degree these variables may independently contribute to the 2-h PG on a statistical basis. Multiple linear regression analysis to elucidate the relationship among some explanatory variables, including FPG, and 2-h PG showed that five independent variables (FPG, age, BMI, serum TG levels, and systolic blood pressure) were all significantly associated with 2-h PG. As expected, the regression procedure indicated FPG as the best predictor of 2-h PG, whereas the former could explain only 41.6% of the variance of the latter. Furthermore, the second and third predictors of 2-h PG were age and BMI, respectively, which could explain 5.2 and 3.3% of the variance of the latter, respectively.

However, because all six variables explained only 43.4% of the total variance in 2-h PG, we speculated that other variables that were not examined in the present analysis may also contribute to 2-h PG. These variables may include fasting or postload insulin levels (33), body fat distribution (34), sympathetic nerve activity (35), level of physical activity (26), and the velocity of glucose absorption by the small intestine (36) during the OGTT test.

As shown in Fig. 2, despite the potential influence of these unassessed confounders, aging, which was found to be the second best predictor of 2-h PG on multiple regression, was significantly associated with increasing ratios of IPH to fasting plus 2-h diabetes. However, this was not true for subjects with BMI of 26 to <28 or those with BMI ≥30, although BMI, the third best predictor, was associated with increasing ratios only in young subjects aged 30–39 years. These results imply that at the least, aging should not be ignored in the diagnosis of IPH. However, it remains to be elucidated whether IPH in the elderly is actually associated with cardiovascular risk; some reports show positive results (37,38) whereas others show partially negative results (15).

In conclusion, these analytical results demonstrated that it is difficult to estimate 2-h PG based on FPG alone because 2-h PG can be influenced by many variables other than FPG, especially by age. Therefore, from the standpoint of not overlooking IPH in undiagnosed individuals, we should perform an OGTT, especially for those of advanced age, even if they show a relatively low FPG level categorized as IFG or normal fasting glucose according to the revised ADA criteria. Finally, the true impact of IPH on the development of diabetic complications has yet to be established, and further research is required.

References

1. The Expert Committee on the Diagnosis and Classification of Diabetes Mellitus: Report of the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. *Diabetes Care* 20:1183–1197, 1997
2. World Health Organization: *Definition, Diagnosis and Classification of Diabetes Mellitus and Its Complications: Report of a WHO Consultation. Part 1. Diagnosis and Classification of Diabetes Mellitus* (WHO/NCD/NCS/99.2). Geneva, World Health Org., 1999
3. Metz CE: Basic principles of ROC analysis. *Semin Nucl Med* 4:283–298, 1978
4. McCance DR, Hanson RL, Charles MA, Jacobsson LTH, Pettitt DJ, Bennett PH, Knowler WC: Comparison of tests for glycated hemoglobin and fasting and two hour plasma glucose concentrations as diagnostic methods for diabetes. *BMJ* 308: 1323–1328, 1994
5. Engelgau MM, Thompson TJ, Herman WH, Boyle JP, Aubert RE, Kenny SJ, Badran A, Sous ES, Ali MA: Comparison of fasting and 2-hour glucose and HbA_{1c} levels for diagnosing diabetes: diagnostic criteria and performance revisited. *Diabetes Care* 20:785–791, 1997
6. Finch CF, Zimmet PZ, Alberti KG: Determining diabetes prevalence: a rational ba-

sis for the use of fasting plasma glucose concentration? *Diabet Med* 7:603–610, 1990
7. Andres R: Aging, diabetes, and obesity: standards of normality. *Mt Sinai J Med* 48: 489–495, 1981
8. Jackson RA: Mechanisms of age-related glucose intolerance. *Diabetes Care* 13 (Suppl. 2):9–19, 1990
9. Ferrara A, Wingard DL, Barrett-Corner E, Shan J: Predictors of change in fasting plasma glucose (FPG) and postchallenge plasma glucose (PCPG) levels in older men and women: the Rancho Bernardo Study 1984–1994 (Abstract). *Diabetes* 45 (Suppl. 2):135A, 1996
10. Barrett-Connor E: Factors associated with the distribution of fasting plasma glucose in an adult community. *Am J Epidemiol* 112:518–523, 1980
11. Andres R: Aging and diabetes. *Med Clin North Am* 55:835–845, 1971
12. Sayetta RB, Murphy RS: Summary of current diabetes-related data from the National Center for Health Statistics. *Diabetes Care* 2:105–119, 1979
13. Pomerleau J, Mckeigue PM, Chaturvedi N: Relationships of fasting and postload glucose levels to sex and alcohol consumption: are American Diabetes Association criteria biases against detection of diabetes in women? *Diabetes Care* 22: 430–403, 1999
14. Barrett-Connor E, Ferrara A: Isolated postchallenge hyperglycemia and the risk of fatal cardiovascular disease in older women and men: the Rancho Bernardo Study. *Diabetes Care* 21:1236–1239, 1998
15. World Health Organization: *Diabetes Mellitus: Report of a WHO Study Group*. Geneva, World Health Org., 1985 (Tech. Rep. Ser., no. 727)
16. Ceriello A: The emerging role of postprandial hyperglycemic spikes in the pathogenesis of diabetic complications. *Diabet Med* 15:189–193, 1998
17. de Vegt F, Dekker JM, Ruhe HG, Stehouwer CD, Nijpels G, Bouter LM, Heine RJ: Hyperglycemia is associated with all-cause and cardiovascular mortality in the Hoorn population: the Hoorn Study. *Diabetologia* 42:926–931, 1999
18. Tominaga M, Eguchi H, Manaka H, Igarashi K, Kato T, Sekikawa A: Impaired glucose tolerance is a risk factor for cardiovascular disease, but not impaired fasting glucose: the Funagata Diabetes Study. *Diabetes Care* 22:920–924, 1999
19. Hanefeld M, Fischer S, Julius U, Schulze J, Schwanebeck U, Schmechel H, Ziegelasch HJ, Lindner J: Risk factors for myocardial infarction and death in newly detected NIDDM: the Diabetes Intervention Study, 11-year follow-up. *Diabetologia* 39:1577–1583, 1996
20. Temelkova-Kurktschiev TS, Koehler C, Henkel E, Leonhardt W, Fuecker K, Hanefeld M: Postchallenge plasma glucose and glycemic spikes are more strongly associated with atherosclerosis than fasting glucose or HbA_{1c} level. *Diabetes Care* 23:1830–1834, 2000
21. Hanefeld M, Temelkova-Kurktschiev T, Schaper F, Henkel E, Siegert G, Koehler C: Impaired fasting glucose is not a risk factor for atherosclerosis. *Diabet Med* 16: 212–218, 1999
22. Beks PH, Mackaay AJ, de Vries H, de Neeling JN, Bouter LM, Heine RJ: Carotid artery stenosis is related to blood glucose level in an elderly Caucasian population: the Hoorn Study. *Diabetologia* 40:290–298, 1997
23. Ito C, Maeda R, Ishida S, Harada H, Inoue N, Sasaki H: Importance of OGTT for diagnosing diabetes mellitus based on prevalence and incidence of retinopathy. *Diabetes Res Clin Pract* 49:181–186, 2000
24. Davidson MB: The effect of aging on carbohydrate metabolism: a review of English literature and a practical approach to the diagnosis of diabetes mellitus in the elderly. *Metabolism* 28:688–705, 1979
25. Jackson RA, Blix PM, Matthews JA, Hamling JB, Din BM, Brown DC, Beilin J, Rubenstein AG, Nabarro JDN: Influence of aging on glucose homeostasis. *J Clin Endocrinol Metab* 55:840–848, 1982
26. Baan CA, Stolk RP, Grobbee DE, Witteman JC, Feskens EJ: Physical activity in elderly subjects with impaired glucose tolerance and newly diagnosed diabetes mellitus. *Am J Epidemiol* 149:219–227, 1999
27. Resnick HE, Harris MI, Brock DB, Harris TB: American Diabetes Association diabetes diagnostic criteria, advancing age, and cardiovascular disease risk profiles: results from the Third National Health and Nutrition Examination Survey. *Diabetes Care* 23:176–180, 2000
28. Lee ET, Howard BV, Go O, Savage PJ, Fabsitz RR, Robbins DC, Welty TK: Prevalence of undiagnosed diabetes in three American Indian populations: a comparison of 1997 American Diabetes Association diagnostic criteria and the 1985 World Health Organization diagnostic criteria: the Strong Heart Study. *Diabetes Care* 23:181–186, 2000
29. Nolan JJ, Ludvik B, Baloga J, Reichart D, Olefsky JM: Mechanisms of the kinetic defect in insulin action in obesity and NIDDM. *Diabetes* 46:994–1000, 1997
30. Boden G: Free fatty acids (FFA), a link between obesity and insulin resistance. *Front Biosci* 15:169–175, 1998
31. Qi C, Pekala PH: Tumor necrosis factor-alpha-induced insulin resistance in adipocytes. *Proc Soc Exp Biol Med* 223:128–135, 2000
32. Gautier JF, Mourier A, de Kerviler E, Tarentola A, Bigard AX, Villette JM, Guezennec CY, Cathelineau G: Evaluation of abdominal fat distribution in noninsulin-dependent diabetes mellitus: relationship to insulin resistance. *J Clin Endocrinol Metab* 83:1306–1311, 1998
33. Zavaroni I, Bonini L, Gasparini P, Barilli AL, Zuccarelli A, Dall'Aglio E, Delsignore R, Reaven GM: Hyperinsulinemia in a normal population as a predictor of noninsulin-dependent diabetes mellitus, hypertension, and coronary heart disease: the Barilla factory revisited. *Metabolism* 48: 989–994, 1999
34. Lamarche B: Abdominal obesity and its metabolic complications: implications for the risk of ischaemic heart disease. *Coron Artery Dis* 9:473–481, 1998
35. Chen JW, Jen SL, Lee WL, Hsu NW, Lin SJ, Ting CT, Chang MS, Wang PH: Differential glucose tolerance in dipper and nondipper essential hypertension: the implications of circadian blood pressure regulation on glucose tolerance in hypertension. *Diabetes Care* 21:1743–1748, 1998
36. Fujita Y, Kojima H, Hidaka H, Fujimiya M, Kashiwagi A, Kikkawa R: Increased intestinal glucose absorption and postprandial hyperglycemia at the early step of glucose intolerance in Otsuka Long-Evans Tokushima Fatty rats. *Diabetologia* 41:1459–1466, 1998
37. Barzilay JI, Spiekerman CF, Wahl PW, Kuller LH, Cushman M, Furberg CD, Dobs A, Polak JF, Savage PJ: Cardiovascular disease in older adults with glucose disorders: comparison of American Diabetes Association criteria for diabetes mellitus with WHO criteria. *Lancet* 354:622–625, 1999
38. Consequences of the new diagnostic criteria for diabetes in older men and women: DECODE Study (Diabetes Epidemiology: Collaborative Analysis of Diagnostic Criteria in Europe). *Diabetes Care* 22:1667–1671, 1999