How to screen and who should be screened for pre-diabetes in Korea?

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Contents

REVIEW ARTICLE

International Journal of Clinical Practice

Prediabetes: a must to recognise disease state

W. Shehab Eldin, M. Emara, A. Shoker

Table 2 Hazards of prediabetes

Risk	Hazards
Total mortality	40% greater than the normal population [17]
Cancer mortality	1.87 times higher than the normal population [45]
Coronary heart disease	1.33 times higher than the normal population [46]
Retinopathy	7.9% of persons with PDM [47]

PDM, prediabetes mellitus.

(Int J Clin Pract 2008:62:642-8)

Standards of Medical Care in Diabetes—2010

American Diabetes Association

Categories of increased risk for diabetes

IFG and IGT should not be viewed as clinical entities in their own right **but rather risk factors for diabetes as well as CVD**.

(Diabetes Care 2010:Suppl1: S11-61)

Table 3—*Categories of increased risk for diabetes

FPG 100–125 mg/dl (5.6–6.9 mmol/l) [IFG]
2-h PG on the 75-g OGTT 140–199 mg/dl (7.8–11.0 mmol/l) [IGT]
A1C 5.7–6.4%

*For all three tests, risk is continuous, extending below the lower limit of the range and becoming disproportionately greater at higher ends of the range.

당뇨병전기 진단의 변화

- ✓ 1979 NDDG : IGT 제시
- ✓ 1997 ADA : Pre-diabetes 제시, 기존 IGT에 IFG 추가함 (110 mg/dL)
- ✓ 2003 ADA : IFG 기준 낮춤: 110->100 mg/dL
- ✓ 2010 ADA : 당뇨병전기 분류에 A1C 추가 (5.7-6.4%)

  명칭 변경 (Categories of increased risk for diabetes)

선별검사법 종류

1 FPG

2 OGTT (2h PG)

3 HbA1C

4. Risk calculators (Questionnaire)

5. 기타: Random plasma glucose (RPG)

Capillary glucose, urine glucose.

선별검사법으로서 **FPG vs 2h PG**

1997 ADA report에서 FPG를 강조한 이유 :

- More convenient for patients
- Less costly and time consuming
- Repeat-test reproducibility is superior than 2h PG.

(Diabetes Care 1997:20:1183-97)

(Diabetes Care 2009:32:1327-34)

A report on the diagnosis of intermediate hyperglycemia in Korea: A pooled analysis of four community-based cohort studies

Jee-Young Oh [a,1], Soo Lim [b,1], Dae Jung Kim [c], Nan Hee Kim [d], Dong Jun Kim [e], Sung Dae Moon [f], Hak Chul Jang [b], Young Min Cho [g], Kee-Ho Song [h], Chul Woo Ahn [i], Yeon-Ah Sung [a], Joong-Yeol Park [j], Chol Shin [d], Hong Kyu Lee [g], Kyong Soo Park [g,*]
on behalf of the Committee of the Korean Diabetes Association on the Diagnosis and Classification of Diabetes Mellitus

✓ 4개 cohort 분석 : 연천, 정읍, 목동, 안산 (총 4610명)

Table 2 – Comparison of the FPG and 2-h PG criteria for the diagnosis of abnormalities in glucose metabolism

	2-h PG			
	<7.8 mmol/L	7.8–11.1 mmol/L	>11.1 mmol/L	Total
FPG				
<5.6 mmol/L	2948 (63.9)	309 (6.7)	41 (0.9)	3298 (71.5)
5.6–6.1 mmol/L	607 (13.2)	169 (3.7)	15 (0.3)	791 (17.2)
6.1–7.0 mmol/L	175 (3.8)	111 (2.4)	47 (1.0)	333 (7.2)
>7.0 mmol/L	26 (0.6)	28 (0.6)	134 (2.9)	188 (4.1)
Total	3756 (81.5)	617 (13.4)	237 (5.1)	4610 (100.0)

Data are *n* (%). FPG, fasting plasma glucose; 2-h PG, 2-h post-load glucose. All cases with incomplete results or previously diagnosed DM patients were excluded.

(DRCP 2008:80:463-8)

HbA1C의 제한점

- Standardization (표준화, 정도관리 문제)
- Misleading in Pts with abnormal red cell turnover
  (anemia, hemoglobinopathies, pregnancy)
- Rapid progression of hyperglycemia in type 1 DM
- Not perfect concordance between A1C and glucose-based test
- Low sensitivity for diagnosing DM than FPG
  (eg) A1c 6.5%를 기준으로 할 경우, 126mg/dl 기준에 의한 당뇨병 환자의 30%가 진단받지 못했음 (미국 NHANES자료)

International Expert Committee Report on the Role of the A1C Assay in the Diagnosis of Diabetes

Table 1—*Advantages of A1C testing compared with FPG or 2HPG for the diagnosis of diabetes*

- Standardized and aligned to the DCCT/UKPDS; measurement of glucose is less well standardized
- Better index of overall glycemic exposure and risk for long-term complications
- Substantially less biologic variability
- Substantially less preanalytic instability
- No need for fasting or timed samples
- Relatively unaffected by acute (e.g., stress or illness related) perturbations in glucose levels
- Currently used to guide management and adjust therapy

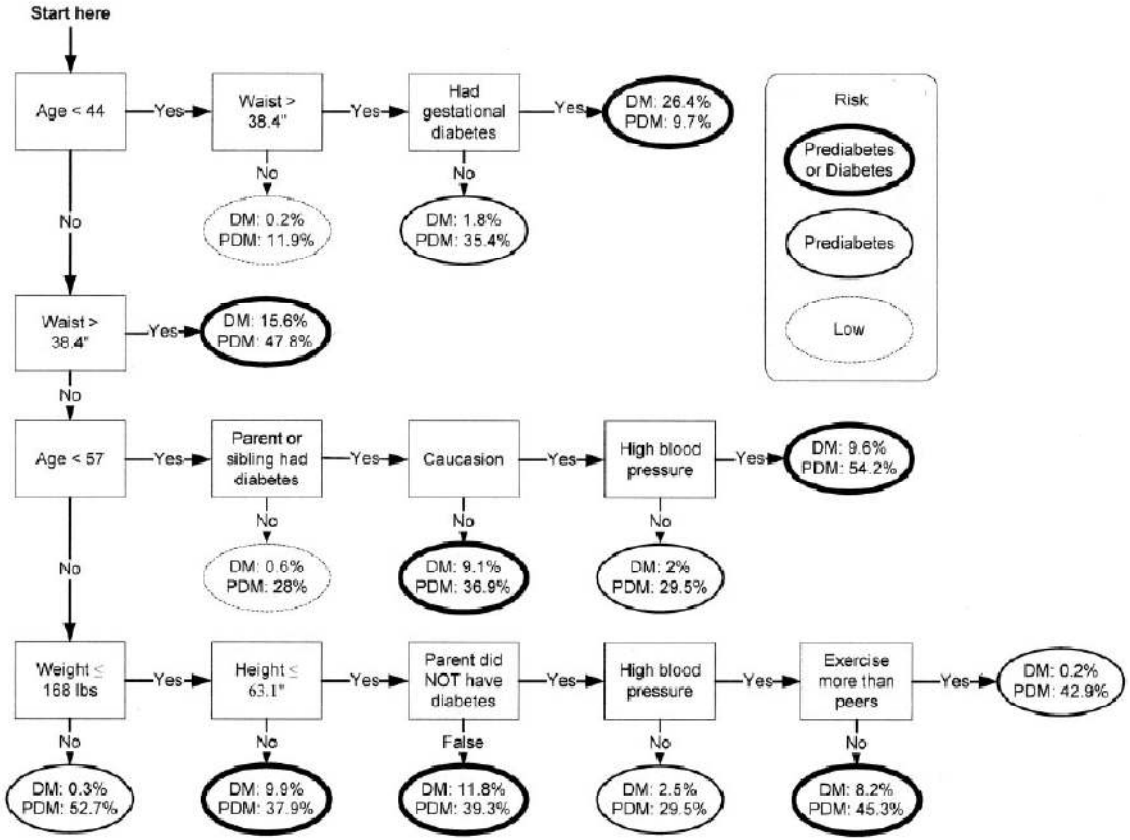
A1C vs FPG 일중 변동치: 2% vs 15%

(Diabetes Care 2009:32:1327-34)

Diabetes Risk Calculator

A simple tool for detecting undiagnosed diabetes and pre-diabetes

- NHANES 1994-2004, ROC 분석
- The Diabetes Risk Calculator is the only currently available noninvasive screening tool designed to detect both pre-diabetes and undiagnosed diabetes in the U.S. population.



igure 1—*Classification tree for detecting pre-diabetes (PDM) or undiagnosed diabetes (DM).*

(Diabetes Care 2008:31:1040–45)

Development and Validation of a Patient Self-assessment Score for Diabetes Risk

- ✓ Cross-sectional data, US adults ≥ 20 yrs.
- ✓ NHANES 2005-2006, ARIC, CHS

Figure. **Self-assessment screening score for undiagnosed diabetes or prediabetes.**

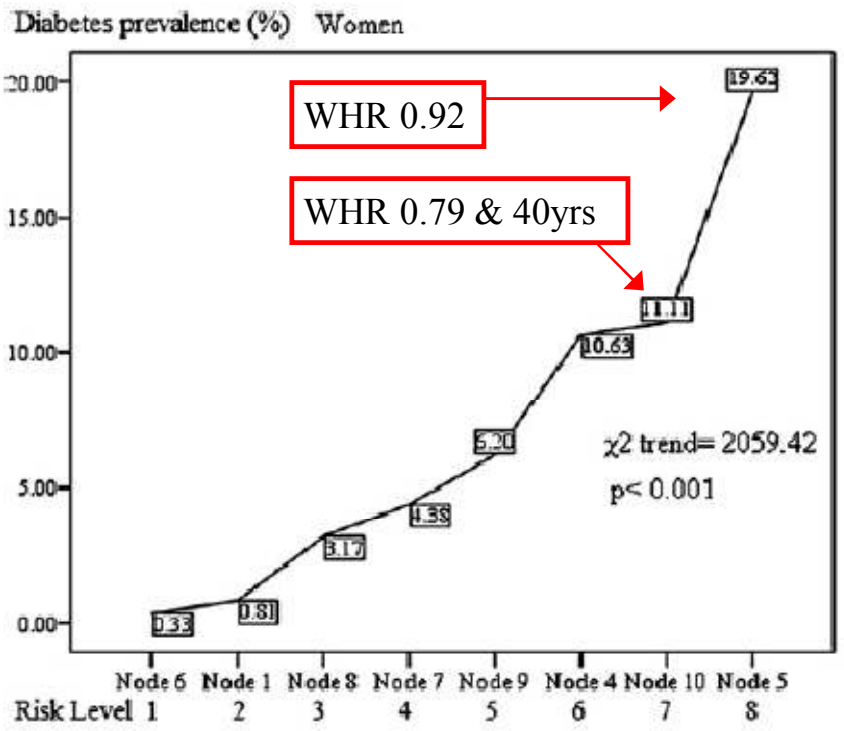
Question	Answer (Score)	Enter Your Score (Enter 0 If You Don't Know)
1. How old are you?	<40 y (0 point) 40–49 y (1 point) 50–59 y (2 points) ≥60 y (3 points)	
2. Are you a woman or man?	Woman (0 point) Man (1 point)	
3. Do your family members (parent or sibling) have diabetes?	No (0 point) Yes (1 point)	
4. Do you have high blood pressure or are you on medication for high blood pressure?	No (0 point) Yes (1 point)	
5. Are you overweight or obese? (see chart below to answer this question more accurately)	Not overweight or obese (0 point) Overweight (1 point) Obese (2 points) Extremely obese (3 points)	
6. Are you physically active?	No (0 point) Yes (–1 point)	
TOTAL SCORE (add points from questions 1–6)		
If your TOTAL SCORE is ≥4, you are at high risk for undiagnosed diabetes or prediabetes. If your TOTAL SCORE is ≥5, you are at high risk for undiagnosed diabetes. See your doctor for a blood test to look for diabetes if your score is high.		

Obesity definitions
Extreme obesity: BMI ≥40 kg/m^2 (men and women), or waist circumference ≥50 in (men) or ≥49 in (women)
Obesity: BMI ≥30 kg/m^2 but <40 kg/m^2 (men and women), or waist circumference ≥40 in but <50 in (men) or ≥35 in but <49 in (women)
Overweight: BMI ≥25 kg/m^2 but <30 kg/m^2 (men and women), or waist circumference ≥37 in but <40 in (men) or ≥31.5 in but <35 in (women)

(Ann Int Med 2009:151:775-83)

A quick self-assessment tool to identify individuals at high risk of type 2 diabetes in the Chinese general population

* Cross-sectional survey : 2000 to 2001 in a nationally representative sample of 15 540 Chinese adults, aged 35-74 yrs.
* diabetes risk level (DRL) using four predictors: age, BMI, WHR, WC



(J Epidem CommHealth 2010: 64::236-42)

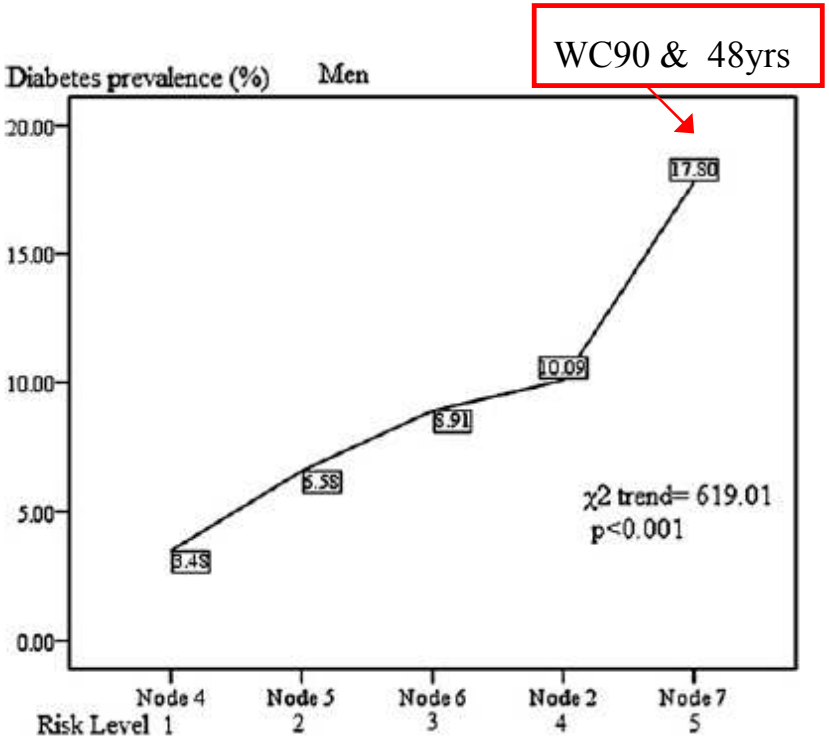


Figure 3 Type 2 diabetes prevalence rates of subgroups with different diabetic risk levels developed by classification and regression tree analysis in women and men.

A New Public Health Tool for Risk Assessment of Abnormal Glucose Levels

(Prevent Chr Dis 2010:7:1-9)

Table 2. AGRA-6 Models[a] for Predicting Abnormal Glucose Levels by Self-Reported Data

Model	Predictive Equation[b]
Model 1: Impaired fasting glucose (IFG)	Log (odds of IFG) = -4.1389 + (0.0366 × [age]) + (0.0419 × [BMI]) + (1.0038 × [male]) –(0.5430 × [NH white]) + (0.0373 × [NH black]) – (0.5875 × [MX American]) + (0.5737 × [HTN meds])
Mode 2: Impaired glucose tolerance (IGT)	Log (odds of IGT) = -4.5598 + (0.0422 × [age]) + (0.0269 × [BMI]) + (0.4958 × [hypertension]) – (0.3946 × [physical activity]) + (0.3449 × [high cholesterol])
Model 3: Prediabetes (PDM)	Log (odds of PDM) = -4.1268 + (0.0444 × [age]) + (0.0408 × [BMI]) + (0.8448 × [male]) – (0.4041 × [NH White]) + (0.1888 × [NH Black]) – (0.4438 × [MX American]) + (0.3685 × [hypertension])
Model 4: High-risk prediabetes (HRP)	Log (odds of HRP) = -6.4083 + (0.0461 × [age]) + (0.0394 × [BMI]) + (0.8947 × [hypertension]) + (0.5428 × [high cholesterol])
Model 5: Undiagnosed diabetes (UDM)	Log (odds of UDM) = -7.6961 + (0.0543 × [age]) + (0.0382 × [BMI]) + (0.9804 × [hypertension]) + (0.2723 × [less HS grad]) + (0.8583 × [HS grad])
Model 6: Total abnormal glucose (TAG)	Log (odds of TAG) = -4.4298 + (0.0486 × [age]) + (0.0493 × [BMI]) + (0.7158 × [male]) – (0.4303 × [NH white]) + (0.1420 × [NH black]) – (0.4397 × [MX American]) + (0.7064 × [hypertension]) + (0.1981 × [high cholesterol]) + (0.4113 × [less HS grad]) + (0.0910 × [HS grad])

Abbreviations: AGRA, Abnormal Glucose Risk Assessment; BMI, body mass index; NH, non-Hispanic; MX, Mexican; HTN meds, hypertension medications; HS grad, high school graduate.
[a] The coefficients in the equations are derived from the optimal logistic prediction models using the Akaike information criterion.
[b] The log (odds of event) is defined as log [P/(1-P)], where P is the probability of an event. Substitute categorical terms with 1 if yes and 0 if otherwise.

Tool to Assess Likelihood of Fasting Glucose ImpairmenT (TAG-IT)

(Am Fam Med 2008:6:555-61)

Table 2. Logistic Regression Model Predicting Fasting Glucose ≥100 mg/dL and Scores Assigned to Each Variable

Characteristic	OR	95% CI	Score
Age, years			
20-27	1.00	—	0
28-35	1.47	1.08-2.00	1
36-44	2.27	1.71-3.03	2
45-64	4.36	3.38-5.64	4
Sex			
Male	2.58	2.24-2.96	3
Female	1.00	—	0
Body mass index (kg/m²)			
<25	1.00	—	0
25-29.9	2.11	1.58-2.65	2
≥30	2.82	2.24-3.55	3
Family history of diabetes			
No	1.00	—	0
Yes	1.27	1.07-1.52	1
Heart rate (beats per min)			
<60	1.12	0.85-1.47	0
60-69	1.00	—	0
70-79	1.38	1.09-1.74	1
80-89	1.56	1.18-2.05	2
90-99	2.20	1.48-3.27	2
≥100	4.02	1.97-8.19	4
Hypertension			
No	1.00	—	0
Yes	1.28	1.02-1.61	1

CI = confidence interval; OR = odds ratio.

OGTT 검사 적응증

(KDA 당뇨병 진료지침, 2007)

1. 공복혈당장애
2. 공복혈당이 정상이더라도, 당뇨병의 고위험군
3. 공복혈당이 유용한 검사가 어려운 60세 이상의 노인인구
4. 혈당검사가 모호하거나, 임신부
5. 역학연구에서 필요할 경우

적절한 선별검사법 : 요약

- ✓ 선별검사로서, FPG, A1C, OGTT가 진단에 서로 보완적인 장점이 있겠음.
- ✓ FPG 측정으로 우선 선별검사를 실시하고, IFG로 나올 경우 OGTT를 추가적으로 실시한다.
- ✓ NGSP 표준화된 방법을 이용하여, A1C를 새로운 선별검사법으로 적용할 수 있겠음.
- ✓ Risk assessment tool의 유용성

Contents

당뇨병전기 진단에 부합하는,

A1C, FPG, 2h PG 수치의 결정 방법

1. 종적연구 :

추후 당뇨병을 예측할 수 있는 적절한 A1C 수치 (FPG, 2h PG) 는 얼마인가?

2. 단면연구 :

IFG (or IGT) 에 가장 부합하는 A1C 수치는 얼마인가?

(비고) ROC 분석 이외에 Cost 고려될 필요 있음.

IFG의 적절수치 결정방법 : F 110->100

(2003 ADA Committee Report)

✓ 추후 당뇨병 발병을 가장 잘 예측하는 기저시점의 FPG 수치를 비교하여 결정함.

✓ ADA: 4개 종족을 조사.

= Dutch population: FPG 103 mg/dL

= Pima Indian : FPG 97 mg/dL

= Mauritius : FPG 94 mg/dL

= San Antonio: FPG 94 mg/dL

-> 100% sensitivity와 100% specificity에 가장 근접한 수치 (100mg/dL)

로 결정함.

Use of HbA_{1c} in Predicting Progression to Diabetes in French Men and Women

- ✓ French cohort study (DESIR), 1,383 men and 1,437 women, aged 30–65 years, for a health exam.
- ✓ Multivariate logistic regression models were used to predict diabetes at 6 years.
- ✓ ROC curves compared the predictive values of A1C and FPG.
- ✓ For A1C, the optimal value was 5.7% (sensitivity 66%, specificity 88%).

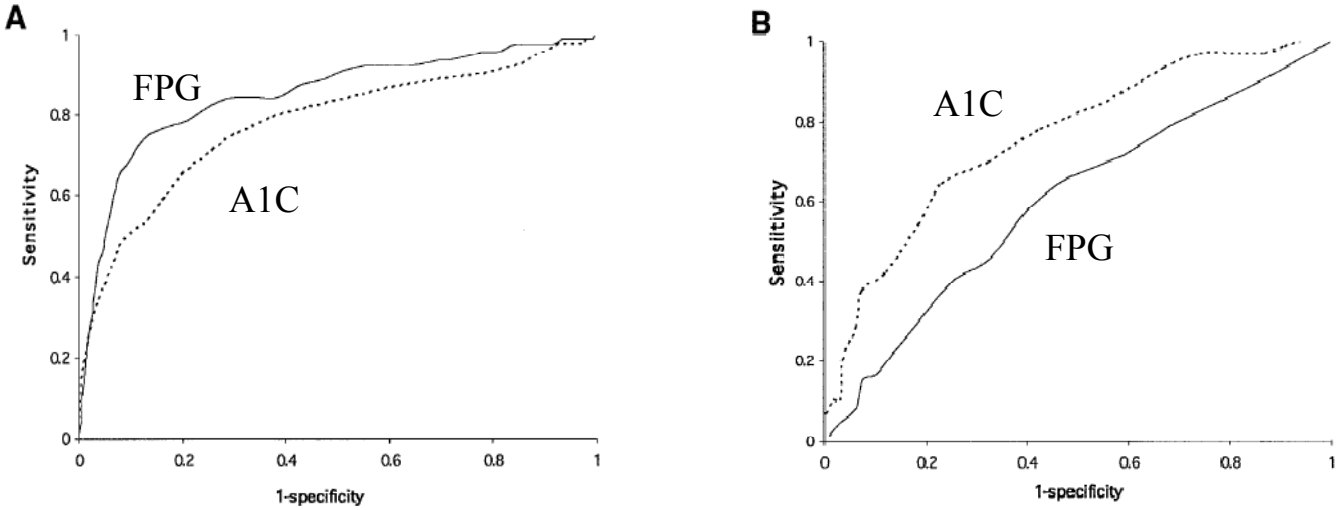


Figure 2—*ROC curves for incident diabetes after 6 years of follow up: A1C (dashed line) and fasting plasma glucose (solid line) in the entire study population (A) and in subjects with IFG (B).*

(Diabetes Care 2006:29:1619–25)

Utility of Hemoglobin A1c in Predicting Diabetes Risk

David Edelman, MD, Maren K. Olsen, PhD, Tara K. Dudley, MStat, Amy C. Harris, BA, Eugene Z. Oddone, MD

(J Gen Intern Med 2004;19:1175–1180)

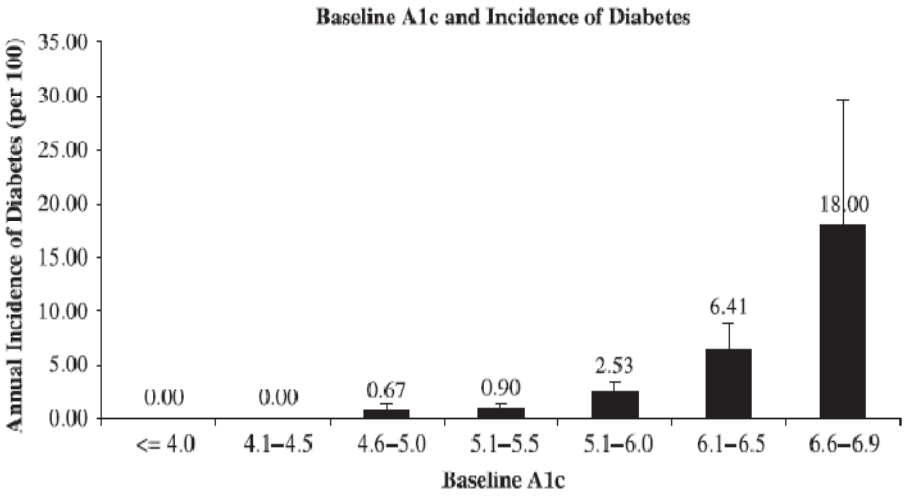


FIGURE 2. Annual incidence of diabetes based on baseline HbA1c. Error bar is +2 S.E.M.

Table 2. Incidence of Diabetes in Patients Based on Baseline Screening HbA1c

HbA1c Category	Incidence per 100 Person-years (95% CI)
Normal (≤ 5.5%)	0.8 (0.4 to 1.2)
High-normal (5.6% to 6.0%)	2.5 (1.6 to 3.5)
Elevated (6.1% to 6.9%)	7.8 (5.2 to 10.4)

$P < .0001$ for difference between groups.

- 1,253 outpatients without diabetes, age 45 to 64. 3yr FU at VAMC.
- Patients with high-normal HbA1c may require FU sooner than 3 years, especially if they are significantly overweight or obese.

Combined Measurement of Fasting Plasma Glucose and A1C Is Effective for the Prediction of Type 2 Diabetes

The Kansai Healthcare Study

(Diabetes Care 2009:32:644–6)

- 6,736 non-diabetic Japanese men aged 40–55 years. 4yr FU

Table 1—*ORs of FPG with A1C and AUROC curve for various models to predict incidence of type 2 diabetes*

	Total	Case	Model 1	Model 2	Model 3	Model 4*	Model 5*	Model 6*
All participants								
FPG (mg/dl)								
≤99	4,147	118 (2.8)	1.00	—	1.00	1.00	—	1.00
100–109	1,863	207 (11.1)	4.27 (3.38–5.39)	—	3.50 (2.75–4.45)	4.06 (3.20–5.14)	—	3.28 (2.57–4.18)
110–125	794	334 (42.1)	24.79 (19.68–31.23)	—	16.00 (12.55–20.40)	22.52 (17.73–28.60)	—	14.54 (11.31–18.68)
A1C (%)								
≤4.9 (5.3)†	2,125	63 (3.0)	—	1.00	1.00	—	1.00	1.00
5.0–5.4 (5.4–5.7)†	3,157	204 (6.5)	—	2.26 (1.70–3.02)	1.82 (1.35–2.46)	—	2.11 (1.58–2.83)	1.71 (1.26–2.31)
5.5–5.9 (5.8–6.2)†	1,239	255 (20.6)	—	8.48 (6.37–11.29)	4.87 (3.60–6.58)	—	7.86 (5.86–10.54)	4.50 (3.30–6.14)
6.0–6.4 (6.3–6.7)†	215	90 (41.9)	—	23.57 (16.29–34.09)	11.72 (7.80–17.59)	—	22.50 (15.27–33.13)	11.04 (7.23–16.87)
≤6.5 (6.8)†	68	47 (69.1)		73.25 (41.33–129.83)	33.14 (17.23–63.75)		75.58 (41.66–137.10)	33.58 (16.88–66.78)
AUROC curve of each model (95% CI)			0.818 (0.800–0.837)	0.771 (0.751–0.792)	0.853 (0.836–0.870)	0.831 (0.814–0.849)	0.789 (0.770–0.809)	0.859 (0.842–0.876)
P value for reference‡			Ref.	<0.001	<0.001	<0.001	0.072	<0.001
Stratified analysis according to FPG								
Participants with FPG ≤99 mg/dl								
FPG, per 5 mg/dl			1.29 (1.06–1.58)	—	1.24 (1.02–1.51)	1.27 (1.04–1.56)	—	1.21 (0.99–1.48)
A1C (%)								
≤4.9 (5.3)†	1,568	21 (1.3)	—	1.00	1.00	—	1.00	1.00
5.0–5.4 (5.4–5.7)†	1,955	37 (1.9)	—	1.42 (0.83–2.44)	1.35 (0.79–2.33)	—	1.32 (0.76–2.27)	1.26 (0.73–2.17)
5.5–5.9 (5.8–6.2)†	535	45 (8.4)	—	6.77 (3.99–11.47)	6.43 (3.79–10.92)	—	6.51 (3.76–11.30)	6.17 (3.54–10.74)
6.0–6.4 (6.3–6.7)†	72	10 (13.9)	—	11.88 (5.37–26.30)	11.30 (5.09–25.08)	—	12.21 (5.32–28.00)	11.44 (4.96–26.37)
≤6.5 (6.8)†	17	5 (29.4)		30.69 (9.93–94.89)	31.89 (10.21–99.59)		39.77 (12.17–129.98)	41.63 (12.68–136.72)
AUROC curve of each model (95% CI)			0.581 (0.526–0.636)	0.717 (0.663–0.770)	0.713 (0.659–0.767)	0.672 (0.621–0.722)	0.740 (0.688–0.792)	0.738 (0.686–0.791)
P value for reference‡			Ref.	<0.001	<0.001	0.004	<0.001	<0.001
Participants with FPG ≥100 mg/dl								
FPG, per 5 mg/dl			2.12 (1.95–2.29)	—	1.92 (1.77–2.09)	2.11 (1.94–2.29)	—	1.93 (1.76–2.10)
A1C (%)								
≤4.9 (5.3)†	557	42 (7.5)	—	1.00	1.00	—	1.00	1.00
5.0–5.4 (5.4–5.7)†	1,202	167 (13.9)	—	1.98 (1.39–2.82)	2.01 (1.39–2.90)	—	1.85 (1.29–2.65)	1.87 (1.29–2.71)
5.5–5.9 (5.8–6.2)†	704	210 (29.8)	—	5.21 (3.66–7.42)	4.27 (2.95–6.18)	—	4.83 (3.36–6.93)	3.94 (2.70–5.74)
6.0–6.4 (6.3–6.7)†	143	80 (55.9)	—	15.57 (9.87–24.57)	10.93 (6.72–17.77)	—	14.40 (8.96–23.16)	10.15 (6.12–16.83)
≤6.5 (6.8)†	51	42 (82.4)		57.22 (26.08–125.53)	28.72 (12.58–65.54)		53.29 (23.86–119.03)	25.51 (10.99–59.23)
AUROC curve of each model (95% CI)			0.749 (0.724–0.773)	0.738 (0.714–0.763)	0.804 (0.782–0.825)	0.773 (0.749–0.796)	0.756 (0.732–0.780)	0.814 (0.792–0.835)
P value for reference‡			Ref.	0.970	<0.001	<0.001	0.995	<0.001

Data are *n*, *n* (%), or OR (95% CI) unless otherwise indicated. *Model included age, BMI, smoking habit (nonsmokers, past smokers, and current smokers), regular leisure-time physical activity, daily alcohol consumption (nondrinkers, light drinkers, moderate drinkers, and heavy drinkers), walk to work (0–10, 11–20, ≥21 min), and parental history of diabetes. †A1C of the National Glycohemoglobin Standardization Program is indicated in parentheses. See research design and methods for help converting A1C (%) of the Japan Diabetes Society to that of the National Glycohemoglobin Standardization Program. ‡*P* value compared with AUROC curve of model 1 by the Sidak method.

Combined Use of Fasting Plasma Glucose and HbA_{1c} Predicts the Progression to Diabetes in Chinese Subjects

* 208 subjects, mean FU 1.6 yrs -> 21.2% DM developed.
* Those who were diabetic at the end of the study had a high likelihood ratio (LR) of 9.3 to have baseline FPG 6.1 mmol/l and baseline HbA1c 6.1%.

Table 2—*Outcomes of the glycemic status of 208 subjects categorized according to baseline FPG and HbA_{1c} concentrations*

	Baseline HbA_{1c} (%)	*n* (%)	OGTT*			LR	Follow-up (years)	Crude rate of progression to diabetes (%/year)
			Normal	IGT	Diabetes			
Baseline FPG (mmol/l)								
≥6.1	≥6.1	21 (10.1)	2	4	15	9.32	1.32 ± 1.20	44.1
≥6.1	<6.1	18 (8.7)	6	8	4	1.06	1.28 ± 0.57	17.4
<6.1	≥6.1	36 (17.3)	17	12	7	0.90	1.42 ± 0.73	13.7
<6.1	<6.1	133 (63.9)	65	50	18	0.58	1.68 ± 1.30	8.1
Total		208	90	74	44		1.60 ± 1.16	13.2

*According to the 1997 ADA criteria: Normal, FPG <7.0 mmol/l and 2-h PG <7.8 mmol/l; IGT, FPG <7.0 mmol/l and 2-h PG ≥7.8 and <11.1 mmol/l; Diabetes, FPG ≥7.0 mmol/l or 2-h PG ≥11.1 mmol/l.

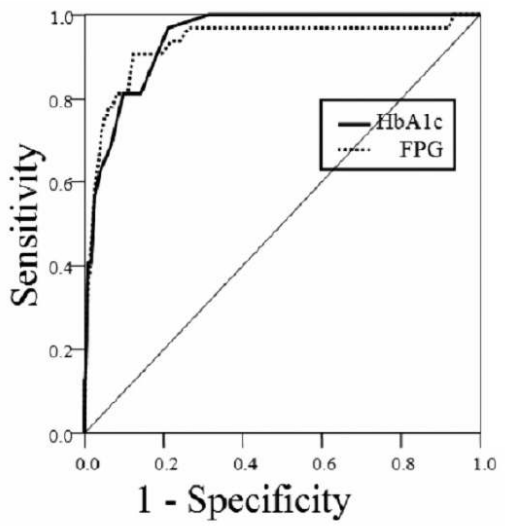
(GARY T.C. KO, *Diab Care 2000:23*:2770-7)

한국 성인에서 제2형 당뇨병의 예측인자로서 공복 혈장 혈당과 당화혈색소의 조합

영남대학교 의과대학 내과학교실[1], 책의학교실[2]

이찬희[1] · 장우진[1] · 정현희[1] · 김현정[1] · 박상현[1] · 문준성[1] · 이지은[1] · 윤지성[1] · 천경아[2] · 원규장[1] · 조인호[2] 이형우[1]

- 건진수진자 2045명. 4년 FU-> 1.6% 발병.
- 추후 당뇨병 발병위험과 관련된 기저 FPG, A1C cut-off 확인



Area under curves of HbAlc & FPG

Variables	AUC	*P*-value
HbAlc	0.944	< 0.001
FPG	0.930	< 0.001

Cut off values of HbAlc

HbAlc	Sensitivity	Specificity
5.25%	100%	68.7%
5.35%	96.6%	78.9%
5.45%	81.3%	85.8%
5.55%	81.3%	90.2%

Cut off values of FPG

FPG	Sensitivity	Specificity
101.5 (mg/dL)	90.6%	85.9%
102.5 (mg/dL)	90.6%	87.7%
103.5 (mg/dL)	81.3%	89.1%

Fig. 1. ROC curves & cut off values of HbA1c & FPG. The predicting cut-off values of HbA1c and FPG are 5 (AUC = 0.94), 102.5 mg/dL (AUC = 0.93) respectively. FPG, fasting plasma glucose.

Conclusion: The combination of HbA1c above 5.35% and FPG above 102.5 mg/dL predicted the onset of diabetes in a Korean sample.

(KDJ 2009:33:306-14)

The Effect of Lowering the Threshold for Diagnosis of Impaired Fasting Glucose

So Hun Kim,[1] Wan Sub Shim,[1] Eun A Kim,[1] Eun Joo Kim,[1] Seung Hee Lee,[1] Seong Bin Hong,[1] Yong Seong Kim,[1] Shin Goo Park,[2] Jong Whan Lim,[2] Hun-Jae Lee,[3] and Moonsuk Nam[1,4]

Table 1. Clinical Characteristics of Subjects (n = 7211) at Baseline and After 2 Years Follow-up

	Baseline	After 2 years	*p* value
Weight (kg)	67.4 ± 10.4	67.9 ± 10.6	< 0.001
BMI (kg/m^2)	23.7 ± 2.9	23.9 ± 2.9	< 0.001
Glucose (mmol/L)	5.15 ± 0.61	5.22 ± 0.65	< 0.001
Total cholesterol (mmol/L)	4.88 ± 0.87	4.92 ± 0.86	< 0.001
Systolic BP (mmHg)	125.0 ± 14.8	129.4 ± 15.4	< 0.001
Diastolic BP (mmHg)	78.2 ± 11.1	77.5 ± 10.8	< 0.001
Frequency of exercise (/wk)	1.36 ± 1.68	1.59 ± 1.71	< 0.001

BMI, body mass index; BP, blood pressure.
Data are expressed as means ± SD.

After 2 years, the baseline FPG level at the point on the ROC curve that was closest to the ideal of 100% sensitivity and 100% specificity was **103 mg/dL** (sensitivity and specificity of 103 mg/dL were 70.3% and 85.4%, respectively).

(Yonsei Med J 2008:49:217-23)

Glycated haemoglobin as a predictor for metabolic syndrome in non-diabetic Korean adults

K. C. Sung and E. J. Rhee

Department of Internal Medicine, Kangbuk Samsung Hospital, Sungkyunkwan University School of Medicine, Seoul, Korea

✓ Methods: In 22 465 selected participants, an analysis was conducted of the ability of HbA1c to predict MS and IFG.

Table 4 ROC curve of HbA_{1c} to predict impaired fasting glucose and metabolic syndrome by two criteria

	Sensitivity/specificity (%)								
	Total			Male			Female		
Cut-offs (%)	ATP III	IDF	IFG	ATP III	IDF	IFG	ATP III	IDF	IFG
5.35	68.1/51.2	71.0/50.5	65.2/56.9	64.9/55.9	68.4/54.9	61.7/63.1	79.8/44	78.5/43.5	75.1/48.3
5.45	57.4/64.3	60.2/63.4	53.7/70.0	53.4/68.7	56.5/67.5	49.9/75.8	72.4/57.5	70.9/56.9	64.3/62
5.55	47.5/75.2	49.9/74.3	42.8/80.6	42.6/78.9	45.1/77.5	38.8/85.2	65.2/69.7	63.8/69	53.9/74.1
5.65	36.6/84	38.4/83.1	32.6/88.6	32.1/86.4	33.8/85.3	29.0/91.7	52.9/80.2	51.7/79.6	42.4/84.3
AUC	64.8	66.1	66.1	64.8	66.0	67.3	71.9	70.4	68.9

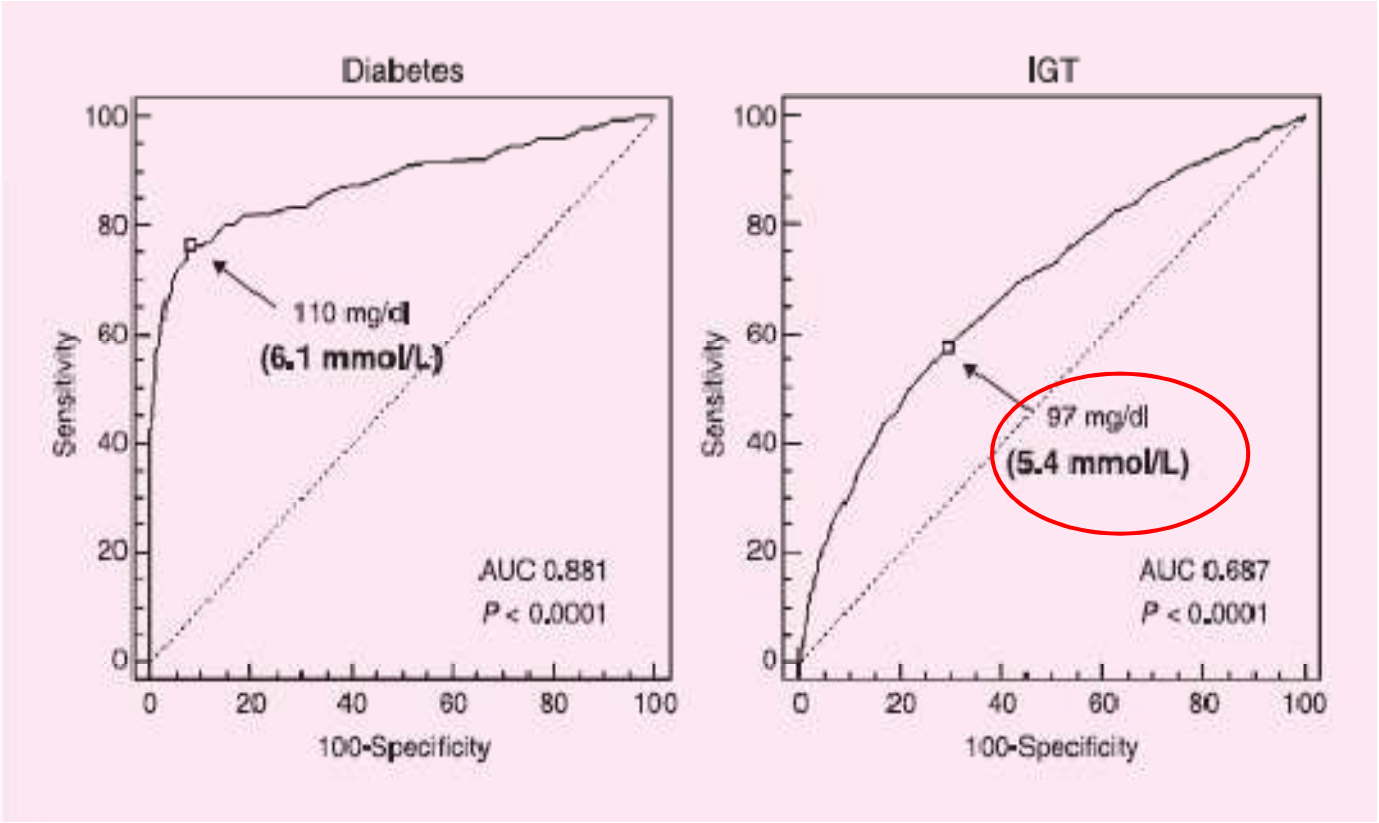
ROC, Receiver–operator curve; ATP, Adult Treatment Panel; IDF, diagnostic criteria for metabolic syndrome from International Diabetes Federation; IFG, impaired fasting glucose; AUC, area under the curve (95% confidence interval).

(Diabet Med 2007:24:848–54)

The diagnosis of diabetes mellitus in Korea: a pooled analysis of four community-based cohort studies

J. Y. Oh, S. Lim*, D. J. Kim†, N. H. Kim‡, D. J. Kim§, S. D. Moon¶, H. C. Jang*, Y. M. Cho*, K. H. Song** and K. S. Park* on behalf of the Committee of the Korean Diabetes Association on the Diagnosis and Classification of Diabetes Mellitus

✓ 4 Cohort study : ROC analysis



(Diabetic Med 2007:24:217-20)

2010 ADA Standards of Medical Care

(Ackerman R.T, Personal communication)

Linear regression analyses of nationally representative U.S. data (NHANES 2005–2006) indicate that among the nondiabetic adult population, an FPG of 110 mg/dl corresponds to an A1C of 5.6%, while an FPG of 100 mg/dl corresponds to an A1C of 5.4%. Receiver operating curve analyses of these data indicate that an A1C value of 5.7%, compared with other cut points, has the best combination of sensitivity (39%) and specificity (91%) to identify cases of IFG (FPG ≥100 mg/dl [5.6 mmol/l]) (R.T. Ackerman, Personal Communication).

2010 ADA Standards of Medical Care

(Ackerman R.T, Personal communication)

Other analyses suggest that an A1C of 5.7% is associated with diabetes risk similar to that of the high-risk participants in the Diabetes Prevention Program (DPP) (R.T. Ackerman, personal communication). Hence, it is reasonable to consider an A1C range of 5.7–6.4% as identifying individuals with high risk for future diabetes and to whom the term pre-diabetes may be applied (6).

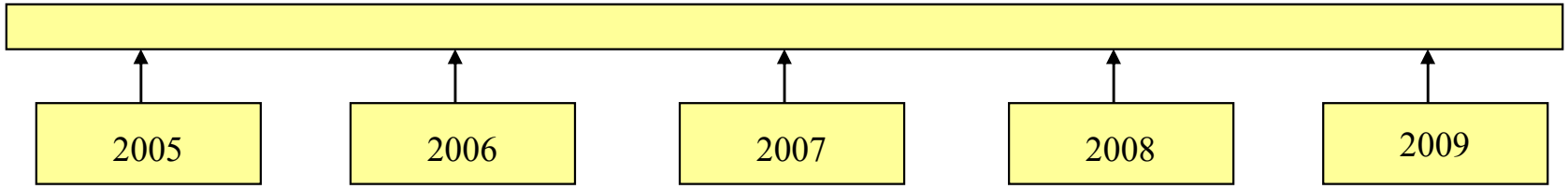
Cut-off Value of A1C and Fasting Glycemia for Predicting New Development of DM in 10513 Koreans : a 4-year Longitudinal Study at KBSMC

성균관의대 강북삼성병원 내분비내과

배지철, 이은정, 이원영, 최지훈, 유승현, 김원준,
박세은, 박철영, 오기원, 박성우, 김선우

연구대상 및 방법

- 대상: 2005-2009년까지 매년 건진을 받은 성인 10950명
  (제외) 기저시점에서의, 당뇨병 환자 437명
  (최종 분석대상) 10513 명



- 4년간 당뇨병 발병: 650명(6.2%)
  당뇨병 발병기준: F ≥ 126 mg/dL, or A1C ≥ 6.5%, or drug Tx Hx.

- 전체 F/U 기간
  – 최장 F/U 기간: 59개월, Median F/U 기간: 54개월

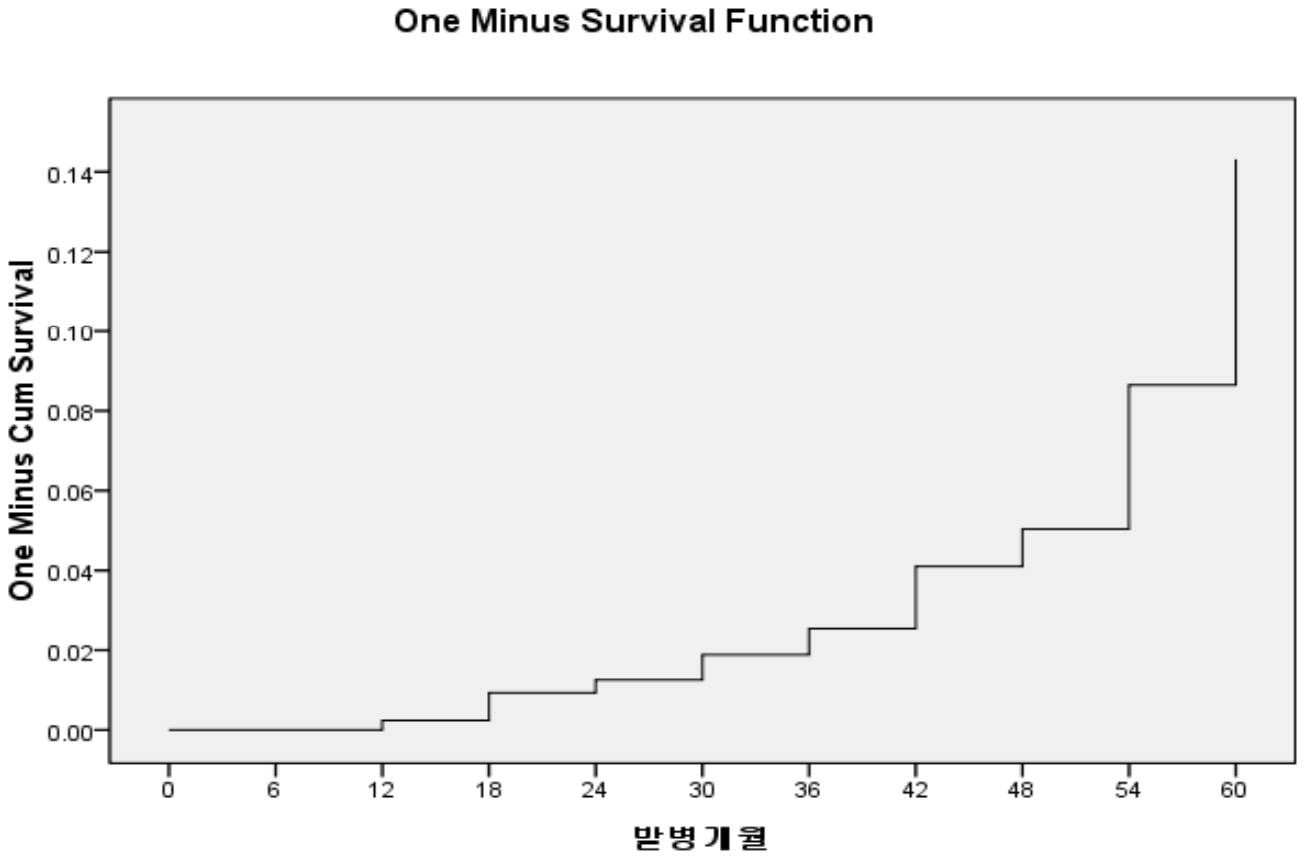
- ROC analysis, Cox-regression, Life table method

Baseline characteristics

Total No.	(N=10513)
Sex (M/F)	7610/2903
Age (yrs)	45.1±5.9
Glucose (mg/dL)	95.4±8.5
T-chol (mg/dL)	193.4±32.2
TG (mg/dL)	134.1±83.1
HDL(mg/dL)	52.1±11.7
LDL (mg/dL)	112.3±27.2
HbA1c (%)	5.38±0.33
BMI (kg/m^2)	23.8±2.8
HOMA-IR	2.04±0.84
No. high risk of DM (Pre-diabetes)	3946(37.5%)

New DM development during 4 yr FU (Life table method)

- Incidence: 1- 생존함수



No. at risk	10513	10513	10488	10415	10381	10315	10192	8060	3315	225

A1C & FBS cut-off value for predicting new development of DM during 4 yr FU : Longitudinal study

AUC of A1C and Fasting glucose

Variables	AUC	P-value
A1C	0.784	< 0.001
Fasting glucose	0.835	< 0.001

A1C	Sensitivity	Specificity
5.55%	70.6%	73.7%
5.65%	62.0%	83.5%
5.75%	52.0%	90.5%

Fasting glucose	Sensitivity	Specificity
101.5 mg/dL	70.7%	81.5%
102.5 mg/dL	68.9%	84.5%
103.5 mg/dL	65.2%	87.1%

Highest Youden Index

A1C cut-off value for predicting IFG (F 100 mg/dL) :

Cross-sectional study

AUC

Variables	AUC	P-value
A1C	0.651	< 0.001

Cut-off values of A1C	Sensitivity	Specificity	
5.35%	70.6%	73.7%	
5.45%	62.0%	83.5%	→ Highest Youden Index
5.55%	52.0%	90.5%	

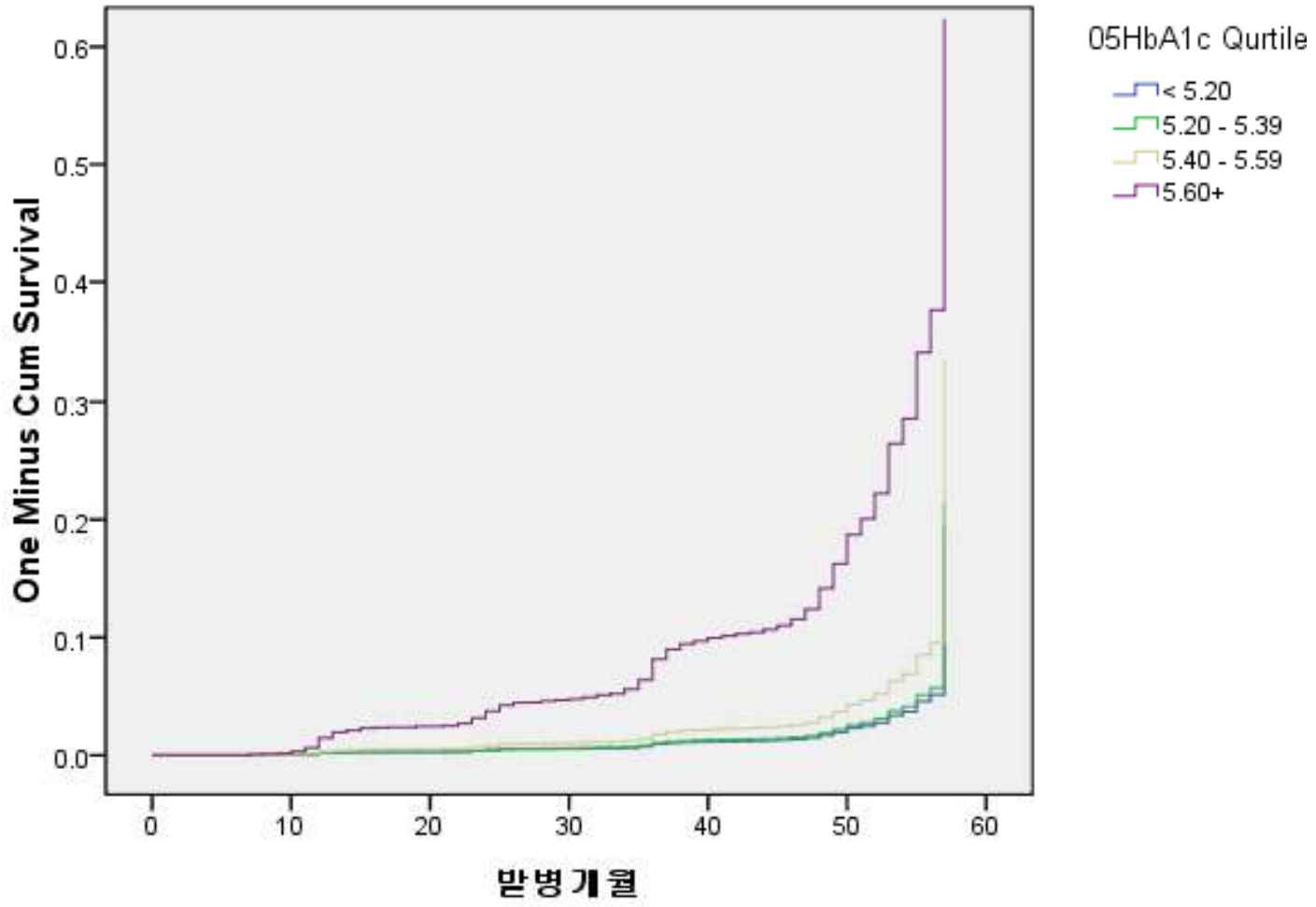
Baseline characteristics : Quartile analysis

	Baseline A1c quartile				
At 2005	<5.2%	5.2-5.4%	5.4-5.6%	≥5.6%	P value
N=9960(%)	2360(23.7%)	2301(23.1%)	2428(24.3%)	2901(28.9%)	
Age	43.9±4.8	44.4±5.1	44.7±5.5	45.9±6.1	<0.001
Male %	80.50%	74.30%	71.70%	67.30%	<0.001
BMI(kg/m^2)	23.5±2.6	23.6±2.7	23.7±2.7	24.3±3.0	<0.001
systolic BP(mmHg)	113.9±14.5	112.6±14.3	112.4±14.2	113.2±14.5	0.001
diastolic BP(mmHg)	76.3±10.3	75.6±10.1	75.4±9.8	75.8±10.1	0.01
HbA1c(%)	4.96±0.17	5.25±0.05	5.45±0.05	5.77±0.19	<0.001
glucose(mg/dL)	92.8±7.4	93.8±7.5	95.2±7.9	99.1±9.5	<0.001
T- chol(mg/dL)	186.3±30.8	191.6±31.1	194.0±31.4	199.8±33.0	<0.001
Triglyceride(mg/dL)	128.3±79.5	128.3±76.3	133.8±81.3	145.0±92.5	<0.001
HDL-C(mg/dL)	51.0±11.4	52.7±12.1	52.2±11.5	52.1±11.8	<0.001
LDL-C(mg/dL)	107.1±26.1	110.7±26.3	112.8±27.1	116.5±27.6	<0.001
HOMA-IR	1.87±0.74	1.95±0.76	2.03±0.83	2.26±0.94	<0.001
Mean folow-up(mon)	48.4±3.1	47.9±3.2	47.5±3.6	45.4±7.8	<0.001

Hazard Ratios for Type 2 Diabetes among 9960 According to quartiles of HbA1c level by Cox regression model

variable	<5.2%	5.2-5.4%	5.4-5.6%	≥5.6%
No of New DM during FU	48	49	84	434
proportion of baseline HbA1c category	2.0%	2.1%	3.5%	15.0%
Person-years of follow-up	9,526	9,192	9,609	10,967
Adjusted risk ratio (95% CI)				
age	1 (reference)	1.10 (0.74-1.64)	1.84 (1.29-2.62)	8.30 (6.15-11.21)
age & sex	1 (reference)	1.15 (0.77-1.71)	1.96 (1.38-2.80)	9.41 (6.96-12.71)
age, sex & BMI	1 (reference)	1.11 (0.77-1.66)	1.83 (1.28-2.61)	8.15 (6.02-11.05)
age, sex, BMI, TG & HDL	1 (reference)	1.12 (0.75-1.67)	1.81 (1.27-2.59)	7.96 (5.87-10.78)

Time-dependent Increase in New DM Development According to Baseline A1C Levels



Cox Regression Analysis of New DM Development (multivariable model except for HOMA-IR)

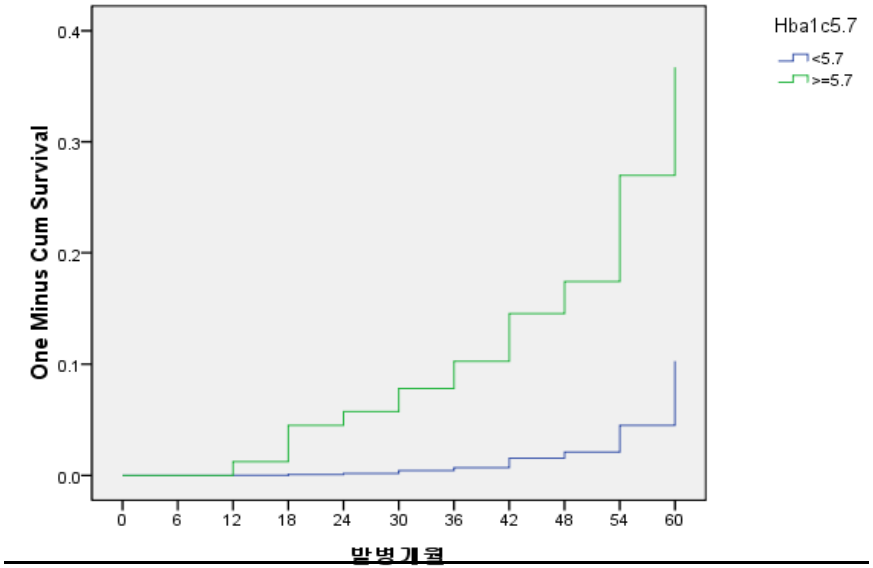
	HR	95% CI	P value
Fasting plasma glucose (per mg/dL)†	1.148	1.138-1.158	<0.001
Age (per year)†	1.031	1.019-1.043	<0.001
Female sex†	1.168	0.925-1.475	0.193
BMI (per kg/m2)†	1.063	1.32-1.096	<0.001
HDL cholesterol (per mg/dL)†	0.987	0.978-0.995	0.002
LDL cholesterol (per mg/dL)†	1.004	1.002-1.007	0.003
Triglycerides (per mg/dL)†	1.001	1.000-1.002	0.002
HOMA-IR *	1.592	1.519-1.669	<0.001

† multivariable analysis
* univariable analysis

* 공복 혈당 1mg/dL 증가 마다 4년 동안, 당뇨병 발병위험은 14.8%씩 증가함

Future DM risk according to Baseline A1c 5.7% :

Hazard ratio (Cox regression model)



*** No. at risk**

<5.7	8060	8060	8059	8053	8046	8025	7958	6302	2570	182
≥5.7	1930	1930	1906	1843	1819	1779	1723	1279	483	15

HbA1c categories	<5.7%	≥5.7%
No of subjects	8060	1930
No of subjects who developed DM	234	381
proportion of baseline HbA1c category	2.90%	19.70%
Person-years of follow-up	28328	10967
Adjusted risk ratio (95% CI)		
age	1 (reference)	6.97 (5.92-8.22)
age & sex	1 (reference)	7.55 (6.40-8.91)
age, sex & BMI	1 (reference)	6.71 (5.67-7.95)
age, sex BMI & HOMA-IR	1 (reference)	6.27 (5.27-7.44)
age, sex, BMI, TG, HDL & HOMA-IR	1 (reference)	6.19 (5.21-7.36)

Hazard Ratios for New Development of DM According to 4 groups categorized by A1c 5.7% and BMI 25 (Cox regression model)

variable	A1c <5.7% BMI <25	A1c <5.7% BMI ≥25	A1c ≥5.7% BMI <25	A1c ≥5.7% BMI ≥25
No of subjects	5583	2418	1120	783
No of subjects who developed DM	124	107	175	201
baseline Pre-diabetes	2.2%	4.4%	15.6%	25.7%
Person-years of FU	24,744	9,631	4,229	2,807
Adjusted RR (95% CI)				
age	1 (reference)	1.93 (1.49-2.50)	7.48 (5.93-9.43)	13.59 (10.84-17.02)
age and sex	1 (reference)	1.70 (1.31-2.21)	8.44 (6.68-10.67)	12.68 (10.11-15.89)
age, sex, TG and HDL	1 (reference)	1.51 (1.16-1.96)	8.04 (6.36-10.18)	10.89 (8.65-13.72)
age, sex, TG, HDL and HOMA-IR	1 (reference)	1.25 (0.95-1.65)	7.71 (6.08-9.78)	8.18 (6.40-10.45)

Summary

1. 종적 연구 :

4년 동안의 당뇨병 발병을 적절히 예측하는, 기저시점의 A1C 및 공복혈당 cut-off level은 각각 5.7%, 103 mg/dL 이었음 (based on highest Youden index).

2. 단면 연구 :

공복혈당 100 mg/dL에 해당되는 A1C는 5.45% 이었음.

3. 다중회귀분석 결과 (종적 연구) :

- 공복혈당 1mg/dL 증가마다 4년 동안, 당뇨병 발병위험은 14.8%씩 증가함.
- A1C 5.7%를 기준으로 이분화 했을 때, 당뇨병 발병위험도가 6.2-6.9배 차이가 있었음.

Suggestion

- ✓ 한국인 중년 성인에서, 당뇨병전기 진단의 적절한 하한 수치는 A1C 5.7%로 제시될 수 있겠음 (추후 당뇨병 발병 예측에 적절한 값).

- ✓ 추가적인 OGTT 검사를 위한 선별 기준으로는 5.45%가 제시될 수 있겠음 (조기진단을 위한 목적).

Contents

The NEW ENGLAND JOURNAL of MEDICINE

Normal Fasting Plasma Glucose Levels and Type 2 Diabetes in Young Men

Men in the Israel Defense Forces who were 26 to 45 years.
A total of 208 incident cases of type 2 DM occurred during 74,309 person-years of follow-up among 13,163 subjects who had baseline FPG < 100 mg/dL.

Table 2. Hazard Ratios for Type 2 Diabetes among 13,163 Men According to Quintiles of Normal Fasting Plasma Glucose Levels.*

Variable	Quintile 1 (N=2529)	Quintile 2 (N=2545)	Quintile 3 (N=2598)	Quintile 4 (N=2719)	Quintile 5 (N=2772)	P Value for Trend
Fasting plasma glucose levels (mg/dl)	50–81	82–86	87–90	91–94	95–99	—
Person-years of follow-up	13,830	13,969	14,631	15,637	16,242	—
No. of incident cases of diabetes	20	24	37	50	77	—
Adjusted risk ratio (95% CI)						
Age	1	1.47 (0.97–2.23)	1.81 (1.16–2.83)	2.33 (1.42–3.83)	3.05 (1.78–5.18)	<0.001
Age and body-mass index	1	1.35 (0.89–2.05)	1.65 (1.06–2.58)	2.17 (1.32–3.56)	2.68 (1.57–4.56)	<0.001
Age, triglyceride level, and body-mass index	1	1.30 (0.86–1.99)	1.58 (1.02–2.48)	2.05 (1.25–3.37)	2.40 (1.40–4.11)	<0.001
Multivariate†	1	1.43 (0.94–2.19)	1.82 (1.16–2.86)	2.64 (1.60–4.37)	2.84 (1.67–4.87)	<0.001

(Tirosh A. NEJM 353:14, 2005)

Table 3. Stratified Analysis of Multivariate Hazard Ratios for Type 2 Diabetes among 13,163 Men According to Quintiles of Normal Fasting Glucose Plasma.*

Variable	Hazard Ratio (95% CI)					P Value for Trend	P Value for Interaction
	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5		
Body-mass index†							
<25	1	1.48 (0.52–4.23)	1.64 (0.54–5.29)	1.71 (0.73–6.42)	1.73 (0.79–6.60)	<0.001	0.03
≥25	1	1.36 (0.86–2.15)	1.66 (1.02–2.68)	2.44 (1.43–4.16)	3.78 (1.95–7.35)	<0.001	
Triglyceride level							
<150 mg/dl	1	1.21 (0.63–2.29)	1.50 (0.76–2.97)	2.43 (1.14–5.23)	2.73 (1.28–6.67)	<0.001	0.87
≥150 mg/dl	1	1.41 (0.80–2.49)	1.90 (1.03–3.51)	2.37 (1.25–4.50)	3.24 (1.48–7.10)	<0.001	
Family history							
Negative	1	1.24 (0.66–2.35)	1.50 (0.78–2.87)	3.77 (1.62–8.77)	6.49 (2.25–18.86)	<0.001	0.37
Positive	1	1.96 (0.77–5.02)	2.51 (0.88–7.19)	2.57 (0.94–6.99)	4.58 (1.58–13.33)	<0.001	

Conclusion: Higher FPG within the normoglycemic range constitute an independent risk factor for type 2 DM, and such levels may help, along with BMI & TG levels, to identify apparently healthy men at increased risk for diabetes.

Normal Fasting Plasma Glucose and Risk of Type 2 Diabetes Diagnosis

Gregory A. Nichols, PhD, Teresa A. Hillier, MD, MS, Jonathan B. Brown, PhD, MPP

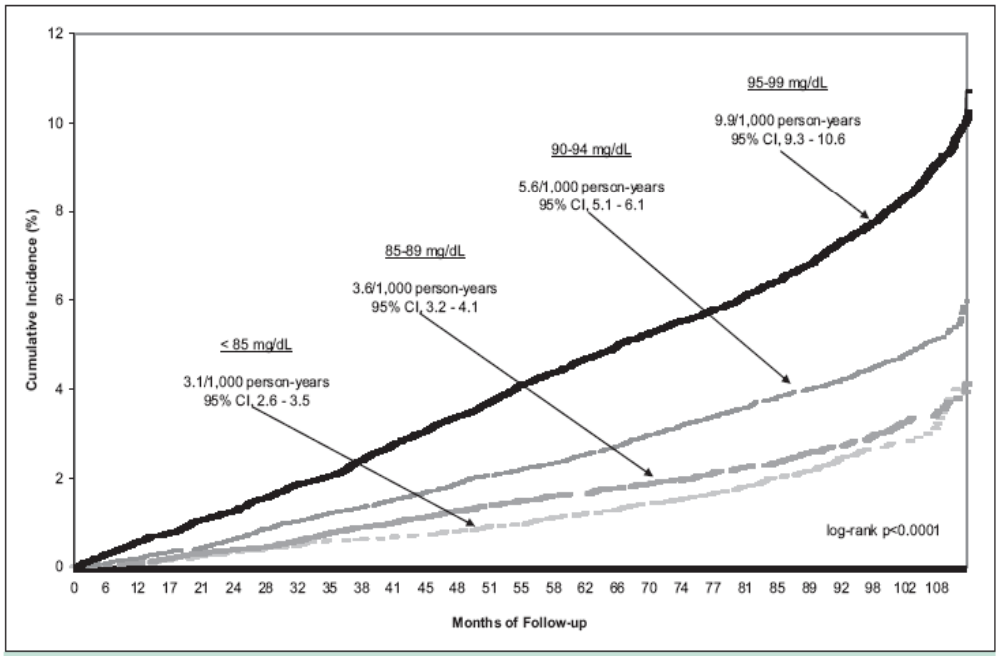


Figure 1 Kaplan-Meier plot of cumulative diabetes incidence by category of normal fasting plasma glucose.

Table 3 Cox Regression Analysis of Diabetes Incidence

	HR	95% CI	*P* value
Fasting plasma glucose (per mg/dL)	1.06	1.05-1.07	<.0001
Age (per year)	1.01	1.00-1.02	<.001
Male sex	1.01	0.90-1.13	.837
BMI (per kg/m^2)	1.08	1.07-1.09	<.0001
Systolic blood pressure (per 5 mm Hg)	1.02	1.01-1.03	.008
HDL cholesterol (per 5 mg/dL)	0.90	0.88-0.92	<.0001
LDL cholesterol (per 10 mg/dL)	0.97	0.96-0.99	.0001
Triglycerides (per 50 mg/dL)	1.09	1.07-1.10	<.0001
Current smoker	1.37	1.22-1.54	<.0001
Diagnosed cardiovascular disease	1.65	1.40-1.93	<.0001
Diagnosed hypertension	1.51	1.35-1.68	<.0001

(Am J Med 2008:121:519-524)

The Cost-effectiveness of Screening for Type 2 Diabetes

CDC Diabetes Cost-Effectiveness Study Group

(JAMA 1998:280:1757-63)

Table 4.—Effects of Screening: Baseline Assumptions and Age-Specific Groups*

	Average Age at Diagnosis, y	Average Age at Death, y	CI ESRD, %	CI Blindness, %	CI LEA, %	CI CVD, %	Life-years	QALYs	Screening Costs, $	Treatment Costs, $	Cost/Life-year Gained, $	Cost/QALY Gained, $
Age ≥25 y												
Without screening	52.71	72.44	3.5	9.1	4.6	42.2	12.33	12.14	...	45 219	...	...
With screening	56.79	72.49	2.6	5.9	3.6	42.3	12.35	12.22	1166	49 608	...	...
Screening effect	−5.92	0.05	−0.9	−3.2	−1.0	0.1	0.02	0.08	1166	3388	236 449	56 649
Age 25-34 y												
Without screening	35.35	62.96	19.2	32.4	19.0	45.3	20.99	20.16	...	97 360	...	...
With screening	29.51	63.33	15.9	25.9	16.0	46.1	21.11	20.51	5933	96 085	...	...
Screening effect	−5.84	0.37	−3.3	−7.5	−2.9	0.8	0.13	0.35	5933	−1275	35 768	13 376
Age 35-44 y												
Without screening	45.41	65.72	10.3	22.4	12.4	46.9	18.06	17.55	...	75 098	...	...
With screening	39.52	65.87	8.0	15.7	10.0	47.1	18.12	17.77	2629	77 456	...	...
Screening effect	−5.88	0.16	−2.3	−6.6	−2.5	0.3	0.06	0.21	2629	1358	64 878	13 707
Age 45-54 y												
Without screening	55.40	68.75	4.2	11.8	6.1	45.2	14.65	14.41	...	53 167	...	...
With screening	49.52	68.80	3.0	8.1	4.6	45.3	14.67	14.50	1006	53 448	...	...
Screening effect	−5.88	0.05	−1.2	−3.8	−1.5	0.1	0.02	0.06	1006	3280	184 839	44 059
Age 55-64 y												
Without screening	55.49	73.02	1.4	5.6	2.8	42.7	11.36	11.26	...	40 254	...	...
With screening	59.53	73.03	0.9	3.5	2.0	42.7	11.37	11.30	715	44 334	...	...
Screening effect	−5.96	0.01	−0.5	−2.1	−0.9	0.0	0.01	0.04	715	4080	681 989	116 908
Age ≥65 y												
Without screening	75.37	78.60	0.3	1.7	1.0	39.8	8.49	8.46	...	27 903	...	...
With screening	69.47	78.60	0.2	1.1	0.7	39.8	8.49	8.47	524	32 490	...	...
Screening effect	−5.90	0.00	−0.1	−0.5	−0.3	0.0	0.00	0.01	524	4587	NA	575 241

*Based on current clinical practice, an average of 10.5 years from onset to diagnosis and a 3% discount rate. CI indicates cumulative incidence; ESRD, end-stage renal disease; LEA, lower-extremity amputation; CVD, cardiovascular disease; QALY, quality-adjusted life-year; and NA, not applicable because denominator is zero. Ellipses indicate data not available.

Method: A Monte Carlo computer simulation model

Result: The incremental cost of opportunistic screening among all persons aged 25 years or older is estimated at $236 449 per life-year gained and $56 649 per QALY gained.

Conclusion: Although current recommendations are that screening begin at age 45 years, these results suggest that screening is more cost-effective at younger ages.

인슐린비의존형 당뇨병의 위험인자 분석

한양대학교 의과대학 내과학교실,[1] 서울대학교 의과대학 내과학교실,[2] 의료관리학교실[3]

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이 종 구[3] · 안 문 영[3] · 김 용 익[3] · 신 영 수[3]

-1992년, 연천지역 주민. 표본추출. OGTT 후 단면분석 (당뇨병의 위험인자)

- 당뇨병: 전체 9.1%, 남성 10.8%, 여성 7.9%,

- IGT: 전체 11.8%, 남성 12.5%, 여성 11.3%

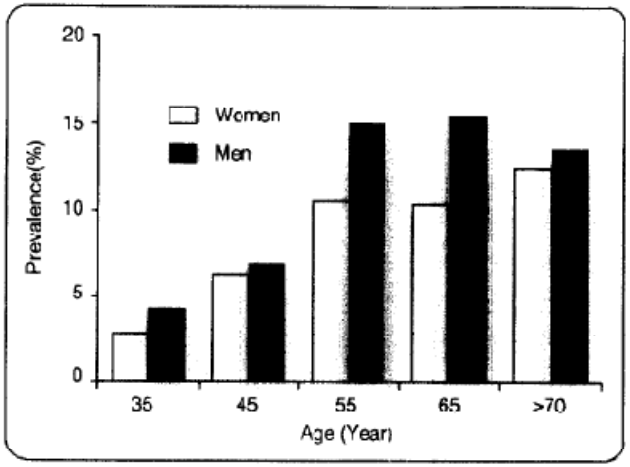


Fig. 1. Prevalence of diabetes mellitus by age and sex in study population. The difference in the prevalence of diabetes by age controlling sex was significant(χ^2trend=58.1, $p<0.001$).

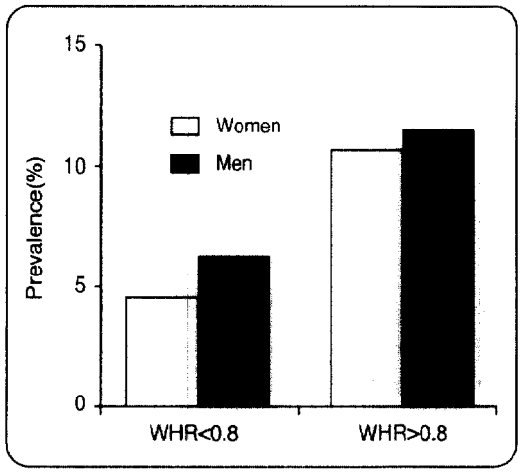


Fig. 2. Prevalence of diabetes mellitus by waist-hip ratio(WHR) and sex in study population. The difference in the prevalence of diabetes by WHR controlling sex was significant(χ^2 trend=24.5, $p<0.001$).

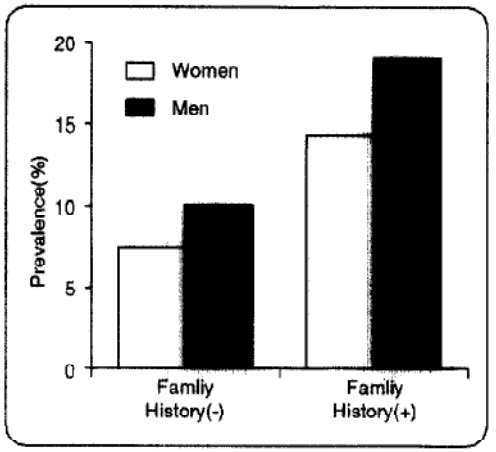


Fig. 3. Prevalence of diabetes mellitus by family history of diabetes and sex in study population. The difference in the prevalence of diabetes by family history of diabetes controlling sex was significant(χ^2 trend=14.1, $p<0.001$).

(당뇨병 1990:20:14-24)

Table 3. Risk Factors of Diabetes Mellitus

Risk Factors	No. of Cases	No. of Controls	POR*	95% CI**
Waist-Hip Ratio				
Quartile 1(<0.83)	23	560	1.0	
Quartile 2(<0.87)	44	578	1.29	0.58~2.89
Quartile 3(<0.91)	43	561	2.66	1.18~5.99
Quartile 4(>0.91)	113	551	3.82	1.37~10.62
Serum triglyceride(mmol/l)				
Tertile 1(<1.11)	43	827	1.0	
Tertile 2(<1.80)	58	740	1.07	0.72~1.61
Tertile 3(>1.80)	122	683	2.02	1.41~2.89
Age(years)				
30~39	21	588	1.0	
40~49	34	484	1.86	0.99~3.52
50~59	86	605	3.66	2.06~6.53
60~69	55	386	3.34	1.81~6.18
>70	31	209	3.27	1.65~6.48
Systolic blood pressure+(mmHg)				
Quartile 1(<110)	21	354	1.0	
Quartile 2(<120)	24	472	1.13	0.75~1.71
Quartile 3(>140)	76	862	1.62	1.03~2.56
Quartile 4(>140)	102	562	1.69	1.01~2.83
Family history of diabetes		2,087		
No	196		1.0	
Yes	25	127	2.1	1.34~3.34
Locality		1,380		
Rural area	119		1.0	
Urban area	108	890	1.56	1.15~2.12

* POR denotes the prevalence odds ratio adjusted for other mentioned variables.

** CI denotes confidence interval.

\+ Treated hypertensives were assigned to the highest quartile of distribution.

(당뇨병 1990:20:14-24)

Table 4—*Criteria for testing for diabetes in asymptomatic adult individuals*

≥ 23kg/m²

1. Testing should be considered in all adults who are overweight (BMI ≥25 kg/m²*) and have additional risk factors:
   - physical inactivity
   - first-degree relative with diabetes
   - members of a high-risk ethnic population (e.g., African American, Latino, Native American, Asian American, Pacific Islander)
   - women who delivered a baby weighing >9 lb or were diagnosed with GDM
   - hypertension (≥140/90 mmHg or on therapy for hypertension)
   - HDL cholesterol level <35 mg/dl (0.90 mmol/l) and/or a triglyceride level >250 mg/dl (2.82 mmol/l)
   - women with polycystic ovary syndrome
   - A1C ≥5.7%, IGT, or IFG on previous testing
   - other clinical conditions associated with insulin resistance (e.g., severe obesity, acanthosis nigricans)
   - history of CVD
2. In the absence of the above criteria, testing diabetes should begin at age 45 years
3. If results are normal, testing should be repeated at least at 3-year intervals, with consideration of more frequent testing depending on initial results and risk status.

*At-risk BMI may be lower in some ethnic groups.

당뇨병의 진단 및 분류 권고안: 배경 및 근거

성연아, 오지영, 김동준[1], 김성훈[2], 김신곤[3], 문성대[4], 이은정[2], 정춘희[5], 홍영선, 대한당뇨병학회 진단소위원회

1. 당뇨병의 선별검사

당뇨병의 선별검사는 공복혈당 혹은 경구당부하 검사로 한다.

연령 40세 이상의 모든 성인과 당뇨병의 위험인자가 있는 30세 이상 40세 미만 성인에서 매년 시행한다.

■당뇨병의 위험인자:

1) 과체중(체질량지수 23 kg/m^2 이상)
2) 당뇨병환자의 직계 가족(부모, 형제, 자매)
3) 공복혈당장애나 내당능장애의 병력
4) 임신성 당뇨병이나 4 kg 이상의 거대아 출산력
5) 고혈압
6) 고밀도지단백콜레스테롤 35 mg/dL 미만 혹은 중성지방 250 mg/dL 이상
7) 인슐린저항성(다낭난소증후군, 흑색가시세포증 등)
8) 혈관질환(뇌졸중, 관상동맥질환 등)

(임상당뇨병 2007:8:17-20)

Contents

DM Screening is infrequent.

- ✓ In one survey in Michigan U health system.:

  Only 70% had any glucose measurement over 3 years by 184 physicians &

  95% of the measurement were RPG. 3% FPG, 2% A1C

(Diabetes Care 2004:27:9-12)

Table 2—*Frequency of follow-up of abnormal screening results within 6 months by age and sex*

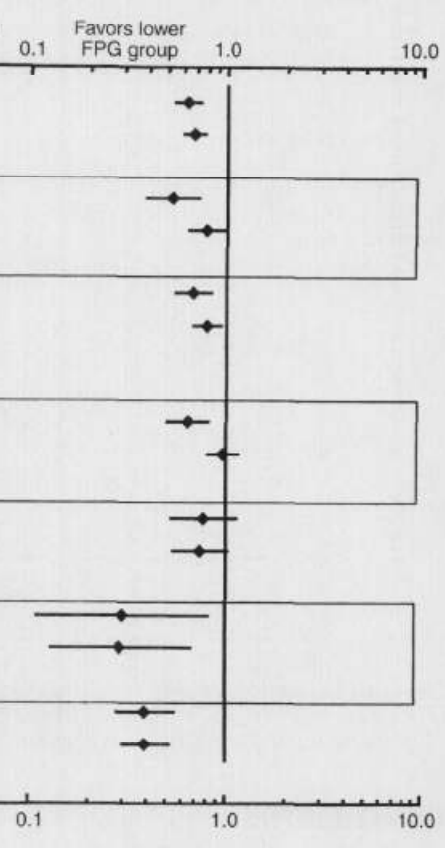
	Screened	Abnormal screening result [*n* (%)]	3 months' follow-up [*n* (% of abnormal)]		6 months' follow-up [*n* (% of screened)]
			Appropriate follow-up	Diagnosis of diabetes	Diagnosis of diabetes
Women					
Age 45–54 years	1,712	38 (2)	12 (32)	7 (18)	7 (0)
Age 55–64 years	783	24 (3)	9 (38)	3 (13)	3 (0)
Age ≥65 years	786	21 (3)	11 (52)	5 (24)	5 (1)
Total	3,281	83 (3)	32 (39)	15 (18)	15 (0)
Men					
Age 45–54 years	1,186	49 (4)	21 (43)	9 (18)	9 (1)
Age 55–64 years	637	18 (3)	7 (39)	5 (28)	5 (1)
Age ≥65 years	648	52 (8)	17 (33)	5 (12)	6 (1)
Total	2,471	119 (5)	45 (38)	20 (17)	20 (1)
Women and men					
Age 45–54 years	2,898	87 (3)	33 (38)	16 (18)	16 (1)
Age 55–64 years	1,420	42 (3)	16 (38)	8 (19)	8 (1)
Age ≥65 years	1,434	73 (5)	28 (38)	11 (15)	11 (1)
Total	5,752	202 (4)	77 (38)	35 (17)	35 (1)

Are Lower Fasting Plasma Glucose Levels at Diagnosis of Type 2 Diabetes Associated With Improved Outcomes?

U.K. Prospective Diabetes Study 61

Table 2—*Proportion of patients with predefined aggregate UKPDS clinical end points classified according to whether they had low (<140 mg/dl [<7.8 mmol/l]), intermediate (140 to <180 mg/dl [7.8 to <10.0 mmol/l]) or high (≥180 mg/dl [≥10.0 mmol/l]) FPG levels at presentation*

	FPG group	*N*	Events	Absolute risk	Odds ratio	95% CI	Log-rank *P*-value
Any diabetes-related end point	Low	692	196	29.3	0.63	0.54 – 0.73	
	Intermediate	1,091	327	31.7	0.68	0.60 – 0.77	
	High	3,305	1310	45.4			<0.00001
Diabetes-related deaths	Low	692	47	6.3	0.53	0.39 – 0.72	
	Intermediate	1,091	107	9.2	0.79	0.64 – 0.98	
	High	3,305	390	11.4			0.00006
All-cause mortality	Low	692	99	13.3	0.68	0.55 – 0.84	
	Intermediate	1,091	179	15.5	0.80	0.68 – 0.94	
	High	3,305	644	18.9			0.00019
Myocardial infarction	Low	692	72	9.9	0.64	0.50 – 0.81	
	Intermediate	1,091	166	14.9	0.96	0.81 – 1.15	
	High	3,305	504	15.3			0.0014
Stroke	Low	692	31	4.2	0.77	0.53 – 1.13	
	Intermediate	1,091	46	4.0	0.74	0.54 – 1.02	
	High	3,305	179	5.3			0.11
Peripheral vascular disease	Low	692	1	0.5	0.30	0.11 – 0.82	
	Intermediate	1,091	6	0.5	0.29	0.13 – 0.67	
	High	3,305	59	1.7			0.00067
Microvascular disease	Low	692	38	5.2	0.39	0.28 – 0.55	
	Intermediate	1,091	58	5.1	0.39	0.30 – 0.52	
	High	3,305	411	12.7			<0.00001



(Diabetes Care 2002:25:1410-7)

Standards of Medical Care in Diabetes—2010

Rationale for 3yr interval screening

The appropriate interval between tests is not known (18). The rationale for the 3-year interval is that false negatives will be repeated before substantial time elapses, and there is little likelihood that an individual will develop significant complications of diabetes within 3 years of a negative test result.

Screening at Health care setting > Community screening

Because of the need for follow-up and discussion of abnormal results, testing should be carried out within the health care setting. Community screening outside a health care setting is not recommended because people with positive tests may not seek, or have access to, appropriate follow-up testing and care. Conversely, there may be failure to ensure appropriate repeat testing for individuals who test negative. Community screening may also be poorly targeted, i.e., it may fail to reach the groups most at risk and inappropriately test those at low risk (the worried well) or even those already diagnosed (19,20).

The Efficacy and Cost of Alternative Strategies for Systematic Screening for Type 2 Diabetes in the U.S. Population 45–74 Years of Age

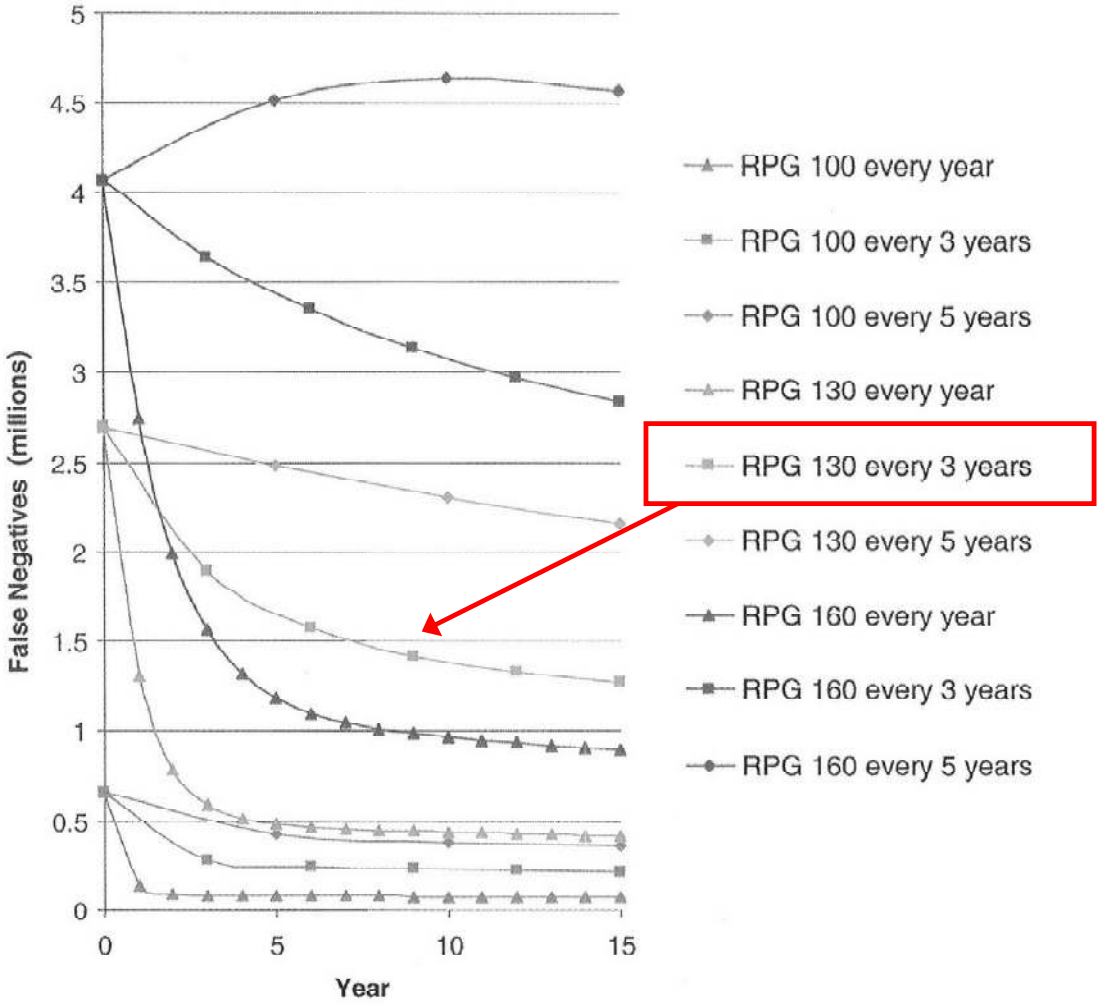


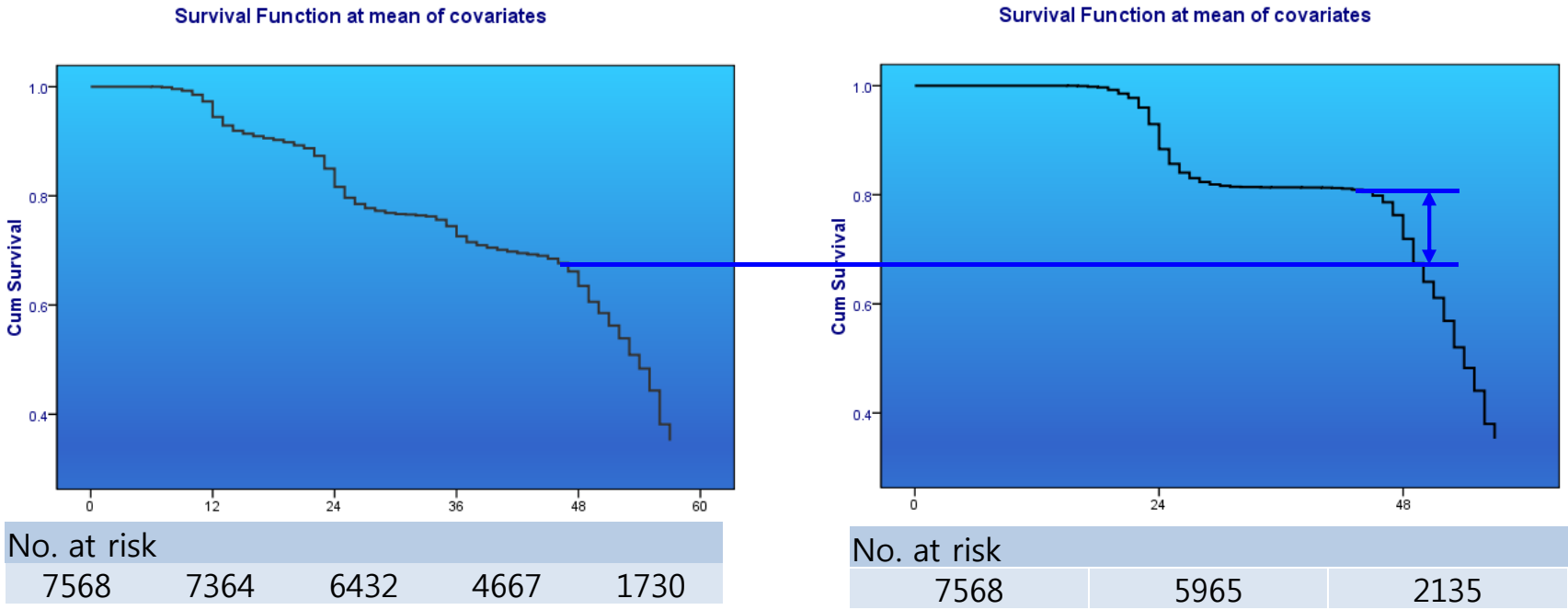
Figure 2—*False negatives at each time point as a function of cut point and frequency of screening.*

Table 1—*Cumulative true-positive and false-positive screening tests*

	True positives (millions)	False-positives (millions)
RPG ≥100 mg/dl		
Every year	18.5	485.9
Every 3 years	18.3	182.3
Every 5 years	18.2	121.6
RPG ≥130 mg/dl		
Every year	18.1	124.2
Every 3 years	17.3	46.5
Every 5 years	16.4	31.3
RPG ≥160 mg/dl		
Every year	17.6	38.1
Every 3 years	15.7	14.3
Every 5 years	14.0	9.5
Equation		
Every year	18.1	38.1
Every 3 years	17.3	14.3
Every 5 years	16.4	9.5

(Diabetes Care 2005:28:307-311)

KBSMC data : Yearly FU vs 2 yr FU for detection of IFG, DM



Diagnosing subjects with ≥ 100mg/dL according to FU interval

F/U interval	1year	2year
No of subjects	7568	7568
No of subjects who developed IFG,DM	2877	2330
proportion of IFG or DM during 4 yrs	38.0%	30.8%
mean month of follow-up	40.5±12.6	43.6±9.7
person-year of F/U	25541	27499

Age at initiation and frequency of screening to detect type 2 diabetes: a cost-effectiveness analysis

Richard Kahn, Peter Alperin, David Eddy, Knut Borch-Johnsen, John Buse, Justin Feigelman, Edward Gregg, Rury R Holman, M Sue Kirkman, Michael Stern, Jaakko Tuomilehto, Nick J Wareham

Summary

Background No clinical trials have assessed the effects or cost-effectiveness of sequential screening strategies to detect new cases of type 2 diabetes. We used a mathematical model to estimate the cost-effectiveness of several screening strategies.

Methods We used person-specific data from a representative sample of the US population to create a simulated population of 325 000 people aged 30 years without diabetes. We used the Archimedes model to compare eight simulated screening strategies for type 2 diabetes with a no-screening control strategy. Strategies differed in terms of age at initiation and frequency of screening. Once diagnosed, diabetes treatment was simulated in a standard manner. We calculated the effects of each strategy on the incidence of type 2 diabetes, myocardial infarction, stroke, and microvascular complications in addition to quality of life, costs, and cost per quality-adjusted life-year (QALY).

Findings Compared with no screening, all simulated screening strategies reduced the incidence of myocardial infarction (3–9 events prevented per 1000 people screened) and diabetes-related microvascular complications (3–9 events prevented per 1000 people), and increased the number of QALYs (93–194 undiscounted QALYs) added over 50 years. Most strategies prevented a significant number of simulated deaths (2–5 events per 1000 people). There was little or no effect of screening on incidence of stroke (0–1 event prevented per 1000 people). Five screening strategies had costs per QALY of about US$10 500 or less, whereas costs were much higher for screening started at 45 years of age and repeated every year ($15 509), screening started at 60 years of age and repeated every 3 years ($25 738), or a maximum screening strategy (screening started at 30 years of age and repeated every 6 months; $40 778). Several strategies differed substantially in the number of QALYs gained. Costs per QALY were sensitive to the disutility assigned to the state of having diabetes diagnosed with or without symptoms.

Interpretation In the US population, screening for type 2 diabetes is cost effective when started between the ages of 30 years and 45 years, with screening repeated every 3–5 years.

Lancet 2010; 375: 1365–74

결론

✓ 적절한 선별검사 및 기준:

- 선별검사로서, FPG, A1C, OGTT가 진단에 서로 보완적인 장점이 있겠음.
- ADA guideline은 5.7-6.4%를 category of increased risk for diabetes로 하였지만, 한국인에서의 적절한 수치에 대한 연구가 진행되어야 하겠음.

✓ 선별검사의 대상 :

- 45세 (vs 40세) 이상 성인 모두.
- 당뇨병 발병 위험인자가 동반된 45세 미만 (vs 40세 미만)

✓선별검사의 간격:

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