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Hemoglobin A1c and glucose criteria identify different subjects as having type 2 diabetes in middle-aged and older populations: The KORA S4/F4 Study

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Abstract

Objective. The American Diabetes Association (ADA) has recently recommended HbA1c for diagnosing diabetes as an alternative to glucose-based criteria. We compared the new HbA1c-based criteria for diagnosis of diabetes and prediabetes with the glucose-based criteria.

Research design and methods. In the population-based German KORA surveys (S4/F4) 1,764 non-diabetic participants aged 31–60 years and 896 participants aged 61–75 years underwent measurements of HbA1c, fasting plasma glucose (FPG), and 2-h glucose.

Results. Only 20% of all subjects diagnosed with diabetes by glucose or HbA1c criteria had diabetes by both criteria; for prediabetes, the corresponding figure was 23%. Using HbA1c $\geq$ 6.5%, the prevalence of diabetes was strongly reduced compared to the glucose criteria (0.7% instead of 2.3% in the middle-aged, 2.9% instead of 7.9% in the older subjects). Only 32.0% (middle-aged) and 43.2% (older group) of isolated impaired glucose tolerance (i-IGT) cases were detected by the HbA1c criterion (5.7% $\leq$ HbA1c $<$ 6.5%).

Conclusion. By glucose and the new HbA1c diabetes criteria, different subjects are diagnosed with type 2 diabetes in middle-aged as well as older subjects. The new HbA1c criterion lacks sensitivity for impaired glucose tolerance.

Key words: *Glycosylated hemoglobin A, impaired fasting glucose, impaired glucose tolerance, normal glucose tolerance, oral glucose tolerance test, type 2 diabetes mellitus*

Introduction

Current World Health Organization (WHO) criteria (1999) for diagnosis of diabetes are based on fasting plasma glucose (FPG) and the oral glucose tolerance test (OGTT) (FPG $\geq$ 7.0 mmol/L and/or 2-h glucose $\geq$ 11.1 mmol/L) (1). However, glucose-based diagnosis of diabetes requires people to fast at least 8 hours before testing, and OGTT is often considered as somewhat cumbersome, whereas HbA1c can be measured at any time, does not require fasting, and shows lower intra-individual biological variability than FPG and 2-h glucose, respectively (2). Standardization of HbA1c measurements has improved in the last years (3), and the American Diabetes Association (ADA) and an International Expert Committee have recently proposed a threshold of HbA1c $\geq$ 6.5% to diagnose diabetes (4,5) as an alternative to the current WHO criteria (1999) (1). For an increased risk of

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Key messages

- In a middle-aged as well as an older German population, use of HbA1c $\geq$ 6.5% for the diagnosis of diabetes leads to a considerably lower prevalence of diabetes than the use of glucose criteria (fasting plasma glucose $\geq$ 7.0 mmol/L and/or 2-h glucose $\geq$ 11.1 mmol/L).
- Groups of subjects identified with diabetes by either the new HbA1c criterion (HbA1c $\geq$ 6.5%) or by glucose criteria overlap to only a small degree.
- The HbA1c criterion for prediabetes (5.7% $\leq$ HbA1c $<$ 6.5%) lacks sensitivity for glucose intolerance as measured by the oral glucose tolerance test, and would miss many persons with impaired glucose tolerance who are the main target group in diabetes prevention programs.

Abbreviations

AROC	area under the receiver operating characteristic curve
BMI	body mass index
DCCT	Diabetes Control and Complications Trial
FPG	fasting plasma glucose
HbA1c	glycosylated hemoglobin A
HDL	high-density lipoprotein
IFG	impaired fasting glucose
i-IFG	isolated impaired fasting glucose
IGT	impaired glucose tolerance
i-IGT	isolated impaired glucose tolerance
KORA	Cooperative Health Research in the Region of Augsburg
NGT	normal glucose tolerance
OGTT	oral glucose tolerance test

diabetes, the ADA suggested HbA1c levels of 5.7%–6.4% as an alternative to WHO criteria for prediabetes (4). In a combined analysis of six studies from Denmark, United Kingdom, Australia, Greenland, Kenya, and India, replacement of glucose criteria by the new HbA1c criterion had different impacts on the diabetes prevalence and on the concordance of the criteria, and varied by ethnicity (6).

Changing diagnostic criteria might also have different consequences for different age-groups, as it is known that older individuals have higher HbA1c levels than younger individuals with similar glucose profiles (7). Therefore, we carried out analyses for two different age-groups (a middle-aged and an older population).

We used data from the German KORA (Cooperative Health Research in the Region of Augsburg) S4/F4 Survey to compare the prevalence of diabetes and prediabetes diagnosed by the WHO glucose and by the new HbA1c criteria, to explore the concordance of the diagnoses by the two criteria, and to compare risk profiles of the subjects identified with diabetes by these alternative criteria.

In the following, 'glucose criteria' refers to the criteria by WHO (1999) (1).

Research design and methods

Study population

KORA S4 Study is a population-based health survey conducted in the city of Augsburg and two surrounding counties between 1999 and 2001. Briefly, a total sample of 6,640 subjects was drawn in a two-stage cluster sample from the target population consisting of all German residents of the region aged 25 to 74 years. Of the randomly selected 6,640 subjects, 4,261 (64.2%) participated in the S4 base-line study. KORA F4 is a follow-up occurring 7 years after the base-line S4.

The current analyses were done for two non-overlapping study groups, a middle-aged one (31–60 years) using data from KORA F4 and an older one (61–75 years) from KORA S4 participants. To avoid effects due to loss to follow-up in the older participants, analyses were carried out with the S4 base-line data. For middle-aged subjects, OGTTs were only performed at follow-up. Thus, only F4 data were used for analyses in the middle-aged participants. In this age-group, loss to follow-up (e.g. mortality) was low.

S4 study group (older participants)

In the KORA S4 survey, OGTTs were only carried out among participants aged 54–75 years without known diabetes. In S4, there were 1,126 participants in the age-group 61–75 years, of whom 120 had known diabetes, and for a further 110 subjects glucose values were missing for various reasons (non-fasting subjects, refusal of OGTT, vomiting during OGTT). For the remaining 896 subjects, base-line data of HbA1c, fasting plasma glucose, and 2-h glucose were available and used for analyses.

KORA F4 study group (middle-aged participants)

Among the 4,261 participants of the S4 base-line study, 3,080 also participated in the 7-year follow-up F4 study. Loss to follow-up was due to subjects who had died in the meantime (n = 176; 4%), lived too far outside the study region or were completely lost to follow-up (n = 206; 5%), or had demanded

deletion of their address data ($n = 12$; 0.2%). Of the remaining 3,867 eligible persons, 174 could not be contacted, 218 were unable to come because they were too ill or had no time, and 395 were not willing to participate in this follow-up, giving a response rate of 79.6%.

Among 3,080 subjects in F4, 1,866 were in the age-range of 31–60 years, of whom 46 had known diabetes, and for a further 56 subjects glucose values were missing for various reasons (non-fasting subjects, refusal of OGTT, vomiting during OGTT). For the remaining 1,764 subjects, complete data on HbA1c, fasting plasma glucose, and 2-h glucose were available and used for analyses.

The investigations were carried out in accordance with the Declaration of Helsinki, including written informed consent of all participants. All study methods were approved by the ethics committee of the Bavarian Chamber of Physicians, Munich.

Ascertainment of diabetes and prediabetes

Self-reported diabetes cases and the dates of diagnosis were validated by contacting the general practitioners, who treated the participants. Among all non-diabetic subjects, OGTT were performed during the morning hours (range 07.00 to 11.00). Participants were asked to fast for at least 10 hours overnight, to avoid heavy physical activity on the day before examination, and to refrain from smoking before and during the test. Exclusion criteria for the OGTT were self-reported diabetes or diabetes treatment, and acute illnesses (infection, fever, acute gastrointestinal diseases). Fasting venous blood glucose was sampled, and 75 g of anhydrous glucose was given (Dextro OGT, Boehringer, Mannheim, Germany).

Diabetes was defined either by the new HbA1c criterion (HbA1c $\geq$ 6.5%) or by glucose criteria (1999) (1,4,5). Using glucose criteria, diabetes was defined by FPG $\geq$ 7.0 mmol/L and/or 2-h glucose $\geq$ 11.1 mmol/L. Prediabetes by HbA1c criteria was defined as 5.7% $\leq$ HbA1c $<$ 6.5% (4). Prediabetes by glucose criteria was divided into isolated impaired fasting glucose (i-IFG), isolated impaired glucose tolerance (i-IGT), and combined impaired fasting glucose (IFG) and impaired glucose tolerance (IGT) (IFG/IGT). I-IFG was defined as FPG $\geq$ 6.1, $<$ 7.0 mmol/L, and 2-h glucose $<$ 7.8 mmol/L. I-IGT was defined as 2-h glucose $\geq$ 7.8, $<$ 11.1 mmol/L, and FPG $<$ 6.1 mmol/L (1).

Fasting and 2-h glucose were measured using a hexokinase method (Gluco-quant; Roche Diagnostics, Mannheim, Germany). The interassay coefficients of variation for glucose were 2.4% at 98 mg/dL and 2.1% at 235 mg/dL (8). In the S4 study, HbA1c was determined using a turbidimetric immunologic assay (Tina-quant II, Roche Diagnostics, Hitachi 717). The Tina-quant, Roche Diagnostics, Hitachi 717 method was considered traceable to the DCCT (Diabetes Control and Complications Trial) reference method by the National Glucose Standardization Program (NGSP), and an equation given by Roche Diagnostics was applied for adaptation to the high performance liquid chromatography (HPLC) method used in the DCCT study. In the F4 study, HbA1c was determined by HPLC (Menarini HA-8160) which is the DCCT standard. In the S4 study, the interassay coefficients of variation were 3.9% at HbA1c 5.7% and 5.2% at HbA1c 9.7%. In the F4 study, the coefficient of variation was 1.2% for lower and higher values of HbA1c. Anthropometric and laboratory measurements have been described in more detail elsewhere (8). Hypertension was defined as blood pressure of 140/90 mmHg or higher, or antihypertensive medication, given that the subjects were aware of being hypertensive.

The area under the receiver operating characteristic curve (AROC) was used to describe the diagnostic utility of HbA1c to identify diabetes cases. The optimal cut-off values for HbA1c for detecting subjects with newly diagnosed diabetes (glucose criteria) were identified using the maximum of the Youden index ((sensitivity + specificity) –1). Age, sex, HbA1c, and components of the metabolic syndrome were compared between subjects diagnosed with diabetes only by the HbA1c criterion, only by glucose criteria, or by both criteria. For these comparisons, F tests were used in case of normally distributed variables; for log-normal variables, F tests were performed on a log-scale. In case of significant global F tests, the Bonferroni method was used for pairwise group comparisons. Logistic regressions were used to compare binomial proportions. All comparisons were adjusted for age and sex.

Analyses were performed using SAS (Version 9.2; SAS Institute Inc., Cary, NC, USA).

Results

The demographic, anthropometric, and clinical characteristics of the subjects are shown in Table I for both age-groups. As expected, the values for body mass index (BMI), waist circumference, glucose levels, HbA1c, and triglycerides are higher in the older population.

Diabetes: prevalence and concordance (HbA1c, glucose criteria)

Glucose criteria detected diabetes in 41 of 1,764 (2.3%) middle-aged subjects, and in 71 of 896 (7.9%)

Table I. Characteristics of the middle-aged and the older cohort: the KORA S4/F4 Study.[a]

	Study group 1 (KORA F4)	Study group 2 (KORA S4)
n	1764	896
Age (years)	47.1 ± 7.9	67.0 ± 3.9
Range of age (years)	31–60	61–75
Male subjects (%)	45.9	51.5
BMI (kg/m^2)	26.8 ± 4.8	28.6 ± 4.1
Waist circumference (cm)	90.5 ± 14.2	96.5 ± 11.2
FPG (mmol/L)	5.17 ± 0.65	5.67 ± 0.83
2-h glucose (mmol/L)	5.74 ± 1.93	7.13 ± 2.59
HbA1c (%)	5.4 ± 0.4	5.6 ± 0.4
Hypertension (%)	21.8	60.0
Triglycerides (mmol/L)[b]	1.09 (0.73, 1.61)	1.30 (0.98, 1.74)
HDL cholesterol (mg/dL)	56.3 ± 14.7	58.2 ± 15.8

[a]Data are means ± standard deviation unless stated otherwise.
[b]Median (first quartile, third quartile).

older subjects (Table II). Using the HbA1c criterion, 12 (0.7%) middle-aged subjects and 26 (2.9%) older subjects were identified as having diabetes. In both study groups combined, 125 were identified with diabetes by either one or both diagnostic criteria, 25 of whom were classified as having diabetes by both criteria (Figure 1).

Prediabetes: prevalence and concordance (HbA1c, glucose criteria)

Using glucose criteria, 198 (11.2%) middle-aged subjects (i-IFG: 56; i-IGT: 122; IFG/IGT combined: 20), and 272 (30.4%) older subjects had prediabetes (i-IFG: 75; i-IGT: 139; IFG/IGT combined: 58), as compared to 257 (14.6%) middle-aged and 390 (43.5%) older subjects who had prediabetes by the HbA1c criterion (5.7% ≤ HbA1c < 6.5%). Among 470 subjects with prediabetes (glucose criteria) only 210 had prediabetes according to both definitions in both study groups together, whereas 437 were identified only by the HbA1c criterion (Figure 2). As can be seen from Table II, 32.0% (middle-aged) and 43.2% (older group) of subjects with i-IGT (WHO) were also detected by the HbA1c criterion for prediabetes. For i-IFG, the corresponding figures were 51.8% and 38.7%, respectively. These proportions were higher for detecting combined IFG/IGT, especially in the middle-aged subjects (Table II).

Measures of diagnostic accuracy

In Table III, measures of diagnostic accuracy are shown for different HbA1c cut-offs with diabetes by glucose criteria as reference: one cut-off is 6.5% as recommended by the ADA, the other is the optimal cut-off as identified by the maximal Youden index (5.7% in the middle-aged, and 6.0% in the older group). With 6.5% as cut-off for HbA1c, sensitivity was poor (0.24, and 0.21), and specificity was close to 1 in both study groups. Due to the small number of false positives, figures for the positive likelihood ratio were very large, whereas figures for the negative likelihood ratio were less favorable due to low sensitivity. Use of the optimal cut-off yielded far better sensitivities (0.80 in middle-aged, and 0.68 in older subjects), but worse specificities (0.86 in both study groups). AROC values for the diagnosis of type 2 diabetes (glucose criteria) by continuous HbA1c values indicated that diabetes by glucose values was better identified in the middle-aged than in the older cohort (AROC 0.92, and 0.82, respectively).

Table II. Diagnosis of prediabetes (glucose criteria) and previously unknown type 2 diabetes (glucose criteria) by HbA1c criteria for prediabetes (5.7% ≤ HbA1c < 6.5%) and for type 2 diabetes (HbA1c ≥ 6.5%) in the middle-aged and in the older cohort (KORA S4/F4).[a]

	NGT	i-IFG	i-IGT	IFG + IGT	FPG ≥ 7.0 mmol/L or 2-h glucose ≥ 11.1 mmol/L	
Middle-aged cohort (31–60 years):						
HbA1c (%)						
< 5.7	1374 (90.1)	27 (48.2)	83 (68.0)	3 (15)	8 (19.5)	1495
≥ 5.7, < 6.5	151 (9.9)	29 (51.8)	39 (32.0)	15 (75)	23 (56.1)	257
≥ 6.5	0	0	0	2 (10)	10 (24.4)	12
	1525	56	122	20	41	1764
Older cohort (61–75 years):						
HbA1c (%)						
< 5.7	328 (59.3)	46 (61.3)	75 (54.0)	17 (29.3)	14 (19.7)	480
≥ 5.7, < 6.5	221 (40.0)	29 (38.7)	60 (43.2)	38 (65.5)	42 (59.2)	390
≥ 6.5	4 (0.7)	0	4 (2.9)	3 (5.2)	15 (21.1)	26
	553	75	139	58	71	896

NGT = normal glucose tolerance; i-IFG = isolated impaired fasting glucose; i-IGT = isolated impaired glucose tolerance; IFG = impaired fasting glucose; IGT = impaired glucose tolerance.
[a]Values are *n* (%) of subjects.

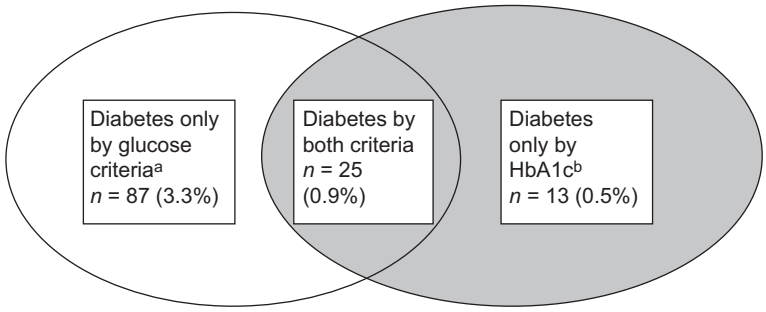

Figure 1. Diabetes by glucose and by HbA1c criteria for both study populations combined (middle-aged population KORA F4, and older population KORA S4). [a]FPG ≥ 7.0 mmol/L and/or 2-h glucose ≥11.1 mmol/L; [b]HbA1c ≥ 6.5%; % refers to the participants in both age-groups (n = 2,660).

Correlation between HbA1c and glucose values

Overall, Spearman correlations between HbA1c and FPG or 2-h glucose were low in both age-groups. In particular, correlation of 2-h glucose with HbA1c was lower than the corresponding coefficients for FPG. Correlations between HbA1c and FPG were 0.43 and 0.27 in the middle-aged and in the older subjects, respectively. Correlations between HbA1c and 2-h glucose were 0.24 in both study groups.

Risk profiles according to criteria of diabetes

When subjects diagnosed with diabetes by either the HbA1c criterion alone, by glucose criteria alone, or by both criteria were compared, global F tests were significant for fasting glucose, 2-h glucose, HbA1c, and triglycerides (Table IV). Subjects diagnosed by both criteria showed the most unfavorable profile for these parameters; for hypertension and high-density lipoprotein (HDL) cholesterol they also had the worst albeit not significantly different values.

Discussion

The groups of subjects identified with diabetes by glucose criteria or by the HbA1c criterion overlapped only to a small extent: Hence, different groups of subjects are identified with diabetes or prediabetes by glucose criteria and the new HbA1c criteria.

Using the HbA1c-based criterion, prevalences of diabetes were much lower compared to glucose criteria in both study groups. A change of the diagnostic criterion would lead to a similar reduction of prevalences in a range of about two-thirds in both age-groups. Using glucose criteria as a reference, the sensitivity of the HbA1c criterion for diabetes was low in both age-groups: less than one in four subjects with diabetes by glucose criteria was diagnosed by the HbA1c criterion. Overall, the two age-groups do not differ with regard to reduction of diabetes prevalence and to sensitivity for diabetes when glucose criteria are the reference and HbA1c is used instead of glucose values.

Furthermore, HbA1c was of low sensitivity in the detection of glucose intolerance in both age-groups: correlations between HbA1c and 2-h glucose were weak, and in the middle-aged group about two-thirds of subjects with isolated IGT were not detected by the HbA1c criterion for prediabetes.

Our results are in line with other studies. Previous studies also found limited detection of diabetes (glucose criteria) by HbA1c levels ≥ 6.5% (9–13). Christensen et al. found considerably lower prevalences of previously undiagnosed diabetes by HbA1c

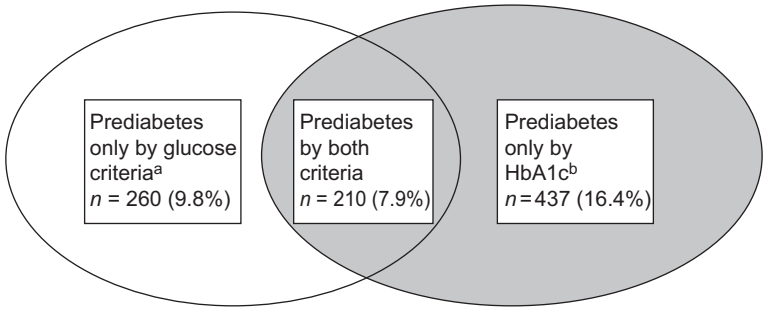

Figure 2. Prediabetes by glucose and by HbA1c criteria for both study populations combined (middle-aged population KORA F4, and older population KORA S4). [a]i-IFG, i-IGT, or IFG/IGT; [b]5.7% ≤ HbA1c < 6.5%; % refers to the participants in age-groups (n = 2,660).

Table III. Diagnostic indices for identification of previously unknown type 2 diabetes (glucose criteria) by different HbA1c cut-offs.

	Study group 1 (KORA F4)	Study group 2 (KORA S4)
HbA1c cut-off		
HbA1c ≥ 6.5%		
Sensitivity	0.24	0.21
Specificity	0.999	0.987
Positive predictive value	0.83	0.58
Negative predictive value	0.98	0.94
LR (+)[b]	210.1	15.8
LR (−)[c]	0.76	0.80
Optimal cut-off for HbA1c[a]	5.7%	6.0%
Sensitivity for optimal cut-off	0.80	0.68
Specificity for optimal cut-off	0.86	0.86
Positive predictive value	0.12	0.30
Negative predictive value	0.99	0.97
LR (+)[b]	5.9	5.0
LR (−)[c]	0.23	0.37

[a]Identified by maximal Youden index = sensitivity + specificity – 1.
[b]Positive likelihood ratio.
[c]Negative likelihood ratio.

≥ 6.5% than by the glucose criteria in four of six ethnic groups (6). In addition, the optimal cut-off points for detection of unknown diabetes (glucose criteria) were also far below 6.5% (9–11,14–16). In addition, there were small correlations between HbA1c and glucose in non-diabetic individuals (9,11), and the ability to identify cases of prediabetes and glucose intolerance by HbA1c was poor (11,17,18).

Identification of different subjects, smaller prevalences of diabetes, or low sensitivities of one diagnostic criterion when another is used as reference are not problems per se. The crucial questions are 1) whether subjects with unfavorable risk profiles are missed by a criterion; 2) whether subjects identified with diabetes by different criteria show different metabolic risk profiles; and 3) whether these non-overlapping groups have different risks for complications.

As for the first point of view, these analyses showed that many subjects with impaired glucose tolerance are missed by the HbA1c criterion for prediabetes. In several studies, it was shown that diabetes can be prevented by life-style interventions in subjects with IGT (19,20). Skipping the OGTT could have as a consequence that a large number of subjects with IGT who could profit from life-style intervention are not identified.

With regard to the second point of view, we compared subjects diagnosed by either one or by both criteria. Subjects diagnosed with diabetes by both criteria had a worse metabolic profile than subjects diagnosed only by one criterion. Between subjects diagnosed by either HbA1c alone, or by glucose values alone, however, we did not observe significant differences apart from 2-h glucose and HbA1c. As there were few subjects diagnosed only by HbA1c it is worthwhile replicating these comparisons with larger samples. Recently, two studies have investigated this question. Borg et al. also found the worst

Table IV. Characteristics of subjects diagnosed with diabetes only by HbA1c, only by glucose criteria, or by both criteria for the middle-aged and the older cohort combined (KORA S4/F4).[a]

	Diagnosis of diabetes only by HbA1c criterion	Diagnosis of diabetes only by glucose criteria	Diagnosis of diabetes by both criteria	*P*
n	13	87	25	
Age	63.9 ± 6.5	63.0 ± 7.6	62.6 ± 9.5	0.83[e]
Sex (male %)	31	60	52	0.15[g]
BMI (kg/m^2)	32.4 ± 9.6	30.9 ± 4.5	30.3 ± 4.5	0.52[e]
Waist circumference (cm)	103.1 ± 21.5	103.7 ± 12.0	102.0 ± 10.1	0.73[e]
Height (cm)	163.1 ± 10.5	166.2 ± 8.7	165.7 ± 8.5	0.81[e]
Hypertension (%)	54	78	84	0.07[g]
Fasting glucose (mmol/L)	5.92 ± 0.72	6.87 ± 0.90	8.82 ± 2.66[c,d]	<0.01[e]
2-h glucose (mmol/L)	8.28 ± 1.78	11.82 ± 2.66[c]	15.79 ± 5.57[c,d]	<0.01[e]
HbA1c (%)	6.7 ± 0.2	5.9 ± 0.3[c]	7.5 ± 1.6[c,d]	<0.01[e]
Triglycerides (mmol/L)[b]	1.44 (1.17, 1.91)	1.62 (1.29, 2.15)	2.14 (1.60, 2.91)[c]	0.01[f]
HDL cholesterol (mg/dL)	50.8 ± 12.2	50.8 ± 15.7	47.0 ± 11.3	0.38[e]

All analyses are adjusted for age and sex, if appropriate.
[a]Mean values ± standard deviation.
[b]Median (first quartile, third quartile).
[c]Significantly different from subjects diagnosed with diabetes only by HbA1c criterion on 5% significance level.
[d]Significantly different from subjects diagnosed with diabetes only by glucose criteria on 5% significance level.
[e]F test.
[f]log F test.
[g]Logistic regression.

risk profile for subjects identified by both criteria (21). Moreover, they found few statistically significant differences in the non-overlapping groups (less hypertension and lower triglyceride values in subjects only identified with HbA1c). Mostafa et al. compared subjects identified with OGTT to subjects additionally identified with HbA1c: the latter had lower waist circumference, lower systolic and diastolic blood pressure, as well as lower levels of triglycerides (22).

As for the third question, little research has been done so far. In our study, we did not have data on retinopathy or other complications. In the Danish Inter99 study, they found that HbA1c was better at discriminating between subjects with high and low risk of developing ischemic heart disease than FPG and 2-h glucose, but these analyses were done with cross-sectional data, and risks were calculated with a prediction score (21). There is still a lack of prospective data to assess the complication risks of subjects identified with diabetes by different diagnostic criteria.

Our study has several limitations. OGTT was performed only once at each stage. HbA1c can be biased by several factors like hemoglobinopathies (like HbS, HbC), hemolytic anemia, major blood loss, or chronic kidney disease, which were not taken into account in our analyses. In the middle-aged study group, the number of diabetes cases by both criteria was small so that some diagnostic indices like the positive predictive value were based on very small figures. The strengths of our studies are the well designed population sample, the measurement of HbA1c in accordance to DCCT standards, and the inclusion of two different age-groups.

In conclusion, this study shows that replacement of glucose criteria by the new HbA1c criteria would have serious consequences for the identification of subjects with diabetes and prediabetes. In our German study groups with middle-aged and older subjects, using the new HbA1c criteria, prevalence of diabetes strongly decreased, whereas prevalence of prediabetes increased. Moreover, the groups of subjects identified by either one or the other criterion overlapped to only a small degree. These results were similar in both age-groups.

Using the HbA1c criterion for prediabetes the majority of subjects with IGT were not detected. This might be a drawback because life-style intervention studies have been successful in preventing or delaying type 2 diabetes in IGT subjects. To assess the implications of our findings, further research is necessary to show whether subjects diagnosed by one or the other criterion differ in their risk profiles, and in their risks of complications.

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