ORIGINAL ARTICLE

Ideal glycated hemoglobin cut-off points for screening diabetes and prediabetes in a Chinese population

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ABSTRACT

Aims/Introduction: The aims of the present study were to evaluate the diagnostic value of fasting plasma glucose, 2-h postload plasma glucose and glycosylated hemoglobin (HbA1c) measurements in the screening of diabetes and prediabetes, and to determine the cut-off point of HbA1c in the diagnosis of diabetes and prediabetes in a Chinese population.

Materials and Methods: A total of 7,611 individuals aged 40 years or older, who did not have a prior history of diabetes, were randomly selected in the Changchun area. For each participant, a questionnaire was completed, and a physical examination and an oral glucose tolerance test were carried out. The values of fasting plasma glucose, 2-h postload plasma glucose and HbA1c were compared by area under the receiver operating characteristic curves. The Youden index was used to identify the optimal cut-off point of HbA1c in the diagnosis of diabetes and prediabetes.

Results: The prevalence of newly diagnosed diabetes and prediabetes was 12.71% and 29.39%, respectively. In participants with newly diagnosed diabetes, the area under the receiver operating characteristic curve was 0.8368 for fasting plasma glucose, 0.9330 for 2-h postload plasma glucose and 0.8064 for HbA1c; whereas for prediabetes, these values were 0.8022, 0.9288 and 0.6895, respectively. In addition, an HbA1c threshold of 6.3% showed the highest Youden index (0.4799) for detecting diabetes; furthermore, an HbA1c threshold of 5.8% showed the highest Youden index (0.2866) for detecting prediabetes.

Conclusions: HbA1c ≥6.3% (45 mmol/mol) and between 5.8% and 6.2% (40–44 mmol/mol) were the optimal cut-off values for the diagnosis of diabetes and prediabetes, respectively, in a Chinese population.

INTRODUCTION

In recent years, diabetes has become a serious public health threat worldwide, leading to increased all-cause mortality, cardiovascular events such as revascularization, chest pain, heart attack, heart failure, stroke and even death in high-risk patients[1–3]. With China's fast economic development, social urbanization, an increased aging population and a major shift towards a Western lifestyle, the prevalence of diabetes has increased dramatically. In 2008, the number of Chinese people who suffered from diabetes mellitus was 92.4 million[4]; and in 2013, the number of diabetic patients increased to 98 million according to the International Diabetes Federation report[5]. Diabetes complications, such as diabetic neuropathy, nephropathy and retinopathy, greatly reduce a patient's quality of life. Prediabetes (intermediate hyperglycemia) is a high-risk state for diabetes when blood glucose levels are higher than normal, but lower than diabetes thresholds. Each year, 5–10% of people with prediabetes will develop diabetes[6]. Therefore, early detection of diabetes and prediabetes with proper interventions will reduce the risk of diabetic complications and mortality[7–9].

Fasting plasma glucose (FPG), 2-h postload plasma glucose (2 h-PPG), and glycosylated hemoglobin (HbA1c) determina-

tion are common methods for screening and diagnosing diabetes. Since 1999, the World Health Organization (WHO) has recommended FPG and 2 h-PPG measurements as gold standards for the diagnosis of diabetes and prediabetes[10]. Later, the American Diabetes Association (ADA) and WHO also recommended the HbA1c measurement as a diagnostic method for diabetes[11,12]. Most previous studies have focused on the evaluation of FPG and HbA1c, mainly because of the lack of a large sample size to study 2 h-PPG. However, as a predictive factor of chronic complications of type 2 diabetes mellitus, the 2 h-PPG measurements have attracted increasing attention in recent years[13,14].

The HbA1c level is not affected by diet, infection or stress; therefore, it can be used as a predictor of chronic complications of diabetes. However, so far, China has not yet established the HbA1c measurement as a diagnostic method for diabetes and prediabetes, mainly because of inadequate standardization of the HbA1c measurement and the lack of enough data to determine the cut-off point for HbA1c[15]. A previous study in Singapore has shown that HbA1c values present significant differences among ethnic groups. For example, under the same conditions, the HbA1c level in Chinese is lower than that in Indians and Malays[16]. Another study also has shown that HbA1c ≥6.5% has a low sensitivity for newly diagnosed diabetes[17]. Meanwhile, there are few studies on the HbA1c diagnostic threshold for prediabetes. Thus, it is critical to establish an appropriate HbA1c diagnostic cut-off for diabetes and prediabetes in the Chinese population using a large sample size.

In the present study, we compared the sensitivity of FPG and 2 h-PPG measurements in screening diabetes and prediabetes, and also compared the sensitivity and specificity of HbA1c with those of FPG and 2 h-PPG measurements. In addition, the optimal cut-off of the HbA1c test was explored for diagnosing diabetes and prediabetes in a population from Changchun, China.

MATERIALS AND METHODS
Study participants
The present work was one part of the baseline survey from the Risk Evaluation of Cancers in Chinese Diabetic Individuals: A Longitudinal Study investigating the association between diabetes and cancer, which was carried out among 259,657 adults, aged years or older from 25 communities across mainland China, from 2011 to 2012[18–20]. A total of 10,175 people were randomly selected from six communities in Changchun, China. They were invited to participate in the present study according to the following criteria: aged 40 years or older; had lived in their current residence for 5 years or longer; and could move freely. The exclusion criteria were as follows: those who were ever diagnosed previously with diabetes; those who had suffered from cardiovascular events, stroke, infection, trauma or surgery in the past 3 months; and those who had a history of anemia or use of glucocorticoids. A total of 9,571 participants (3,161 men and 6,410 women) completed the study. After the exclu-

sion of 1,509 subjects, who had a previous history of diabetes, and 451 subjects, for whom data on fasting, 2-h plasma glucose levels or HbA1c were missing, 7,611 adults (2,435 men and 5,176 women) were included in the final analysis for the present study.

Ethics Statement
The Ruijin Hospital Ethics Committee of Shanghai Jiao Tong University School of Medicine approved the study protocol. Written informed consent was obtained from each participant before data collection.

Study design and laboratory testing
Each participant received a physical examination including measurements of height, weight, waist circumference, hip circumference and blood pressure, and completed a questionnaire including basic personal information, and history of diabetes and family diseases. After an overnight fast of 8–14 h, a venous blood sample was collected to measure the levels of FPG, triglycerides, total cholesterol, low-density lipoprotein cholesterol and high-density lipoprotein cholesterol. In addition, a fingertip blood sample was collected, prepared, stored and transported as per the standard protocol using the Hemoglobin Capillary Collection System (Bio-Rad Laboratories, Hercules, CA, USA) for measurement of HbA1c. Next, each participant was given a standard 75-g glucose solution orally for the glucose tolerance test. To measure 2 h-PPG, blood samples were collected 2 h after the glucose load.

Plasma glucose concentrations were measured by the glucose oxidase method (Bayer ADVIA2400, Leverkusen, Germany)[21] in collaboration with the Central Laboratory of the First Hospital of Jilin University. The measurements of triglycerides, total cholesterol, low-density lipoprotein cholesterol and high-density lipoprotein cholesterol were carried out using an enzymatic colorimetric method (LX-20; Beckman, Brea, CA, USA) by the Shanghai Institute of Endocrinology and Metabolism; and the measurement of HbA1c was carried out by a high-performance liquid chromatography method (Bio-Rad Laboratories, Hercules, CA, USA)[22].

Diagnostic criteria
The glycemic thresholds for the diagnosis of diabetes and impaired glucose regulation were based on the 1999 WHO criteria. The diagnostic criteria and subgroups are described in Table 1.

Statistical analysis
Statistical analyses were carried out using SPSS (version 18.0; IBM Corporation, Armonk, NY, USA) and open-source R (version 2.15.1; Auckland University, Auckland, New Zealand) software. Data were plotted with Graph Pad Prism software (version 5.0; GraphPad Software; La Jolla, CA, USA). Continuous variables are presented as the mean ± standard deviation; the *t*-test was used for comparison between two groups, and

the F-test (analysis of variance) was used for comparison of groups of more than two. Categorical variables were expressed as percentages. The χ^2-test was used for comparison between multiple groups. A P-value <0.05 was considered statistically significant.

The receiver operating characteristic (ROC) curves were achieved using open-source R software (version 2.15.1; Auckland University) and the p-ROC package[23]. In the present study, two ROC curves were plotted: one for people diagnosed with diabetes, and the other for people diagnosed with prediabetes by FPG, 2 h-PPG and HbA1c, respectively. In general, an area under the curve (AUC) >0.9 indicates a high diagnostic value, 0.7 < AUC ≤ 0.9 indicates a moderate diagnostic value, and 0.5 < AUC ≤ 0.7 indicates a low diagnostic value. Optimal cut-off values were obtained based on the highest Youden index across various cut-off points as reviewed previously[24].

RESULTS

The final analysis included 7,611 participants (2,435 men and 5,176 women). Table 2 shows the clinical characteristics of the participants. No differences were detected in 2 h-PPG and HbA1c levels between men and women. However, the levels of FPG, triglycerides, age, systolic/diastolic pressure, body mass index and waist-to-hip ratio were considerably higher in men compared with women; whereas the levels of high-density lipoprotein cholesterol, low-density lipoprotein cholesterol and total cholesterol were significantly higher in women compared with men.

Table 1 | Diagnostic criteria and subgroups of prediabetes and diabetes

Diagnosis		Criteria
Normal glucose tolerance		FPG < 6.1 mmol/L, and 2 h-PPG < 7.8 mmol/L
Prediabetes	Isolated impaired fasting glucose	6.1 mmol/L ≤ FPG < 7.0 mmol/L, and 2 h-PPG < 7.8 mmol/L
	Isolated impaired glucose tolerance	FPG < 6.1 mmol/L, and 7.8 mmol/L ≤ 2 h-PPG < 11.1 mmol/L
	Combined impaired fasting glucose and impaired glucose tolerance	6.1 mmol/L ≤ FPG < 7.0 mmol/L, and 7.8 mmol/L ≤ 2 h-PPG < 11.1 mmol/L
Diabetes mellitus	DM diagnosed depending merely on FPG (DM1)	FPG ≥ 7.0 mmol/L, and 2 h-PPG < 11.1 mmol/L
	DM diagnosed depending merely on 2 h-PPG (DM2)	FPG < 7.0 mmol/L, and 2 h-PPG ≥ 11.1 mmol/L
	Both levels of FPG and 2 h-PPG reach DM criteria (DM3)	FPG ≥ 7.0 mmol/L, and 2 h-PPG ≥ 11.1 mmol/L

2 h-PPG, 2 h postload plasma glucose; DM, diabetes mellitus; DM1, type 1 diabetes mellitus; DM2, type 2 diabetes mellitus; DM3, type 3 diabetes mellitus; FPG, fasting plasma glucose.

Table 2 | Clinical characteristics of the participants

Characteristics	Total	Men	Women	P-value
n	7,611	2,435	5,176	
Age (years)	57.77 ± 9.64	59.15 ± 10.08	57.13 ± 9.36	<0.001
Systolic pressure (mmHg)	140.03 ± 21.79	143.06 ± 21.00	138.61 ± 22.00	<0.001
Diastolic pressure (mmHg)	80.33 ± 11.89	83.35 ± 11.62	78.92 ± 11.75	<0.001
Body mass index (kg/m^2)	24.89 ± 3.72	25.29 ± 3.82	24.71 ± 3.66	<0.001
Waist-tp-hip ratio	0.859 ± 0.073	0.882 ± 0.077	0.849 ± 0.069	<0.001
FPG (mmol/L)	5.76 ± 1.16	5.90 ± 1.30	5.70 ± 1.09	<0.001
2 h-PPG (mmol/L)	7.67 ± 3.11	7.66 ± 3.35	7.67 ± 2.99	0.879
HbA1c (% mmol/mol)	5.87 ± 0.74	5.85 ± 0.77	5.88 ± 0.72	0.067
HDL-C (mmol/L)	1.31 ± 0.30	1.23 ± 0.29	1.35 ± 0.29	<0.001
LDL-C (mmol/L)	2.93 ± 0.75	2.85 ± 0.74	2.97 ± 0.76	<0.001
CHOL (mmol/L)	5.14 ± 0.94	4.97 ± 0.91	5.21 ± 0.95	<0.001
TG (mmol/L)	1.74 ± 1.27	1.85 ± 1.53	1.69 ± 1.13	<0.001
Normal glucose tolerance	4,407 (57.90%)	1,345 (55.23%)	3,062 (59.16%)	<0.001
Prediabetes	2,237 (29.39%)	728 (29.90%)	1,509 (29.15%)	
Diabetes	967 (12.71)	362 (14.87%)	605 (11.69%)	

2 h-PPG, 2 h postload plasma glucose; CHOL, cholesterol; DM, diabetes mellitus; DM1, type 1 diabetes mellitus; DM2, type 2 diabetes mellitus; DM3, type 3 diabetes mellitus; FPG, fasting plasma glucose; HbA1c, glycosylated hemoglobin; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TG, triglyceride.

In the present study, we identified a total of 4,407 (58%) participants with normal glucose tolerance, 2,237 (29%) with prediabetes and 967 (13%) with diabetes (Table 2). We found that the prevalence of diabetes and prediabetes increased with age (Figure 1a); and the prevalence of diabetes in men was higher than that in women (Figure 1b). Furthermore, based on the subgroups in Table 1, the prevalence of isolated impaired fasting glucose (iIFG), isolated impaired glucose tolerance (iIGT), and the combination of iIFG and iIGT was 7.15%, 15.24%, and 7.52%, respectively, in men, and the prevalence in women was 4.66%, 18.88% and 5.62% (Figure 2a). Meanwhile, the prevalence of type 1 diabetes mellitus, type 2 diabetes mellitus and type 3 diabetes mellitus was 2.51%, 5.75% and 6.61% in the male population, and the prevalence was 1.78%, 5.24% and 4.68% in the female population, respectively. Together, these data suggested that among all types of dysglycemia, the proportion of respondents with abnormal 2 h-PPG levels was relatively high.

In contrast, the proportions of isolated postload hyperglycemia were higher than that of isolated fasting hyperglycemia in diabetic and prediabetic participants among all adult age groups, regardless of sex (Figure 3). It was found that 31.2–58.8% of diabetic patients suffer from isolated postload hyperglycemia, and that 41.1–68.7% of prediabetic patients suffer from isolated postload hyperglycemia.

As shown in Figure 4, the ROC curves represent the diagnostic ability of FPG, 2 h-PPG and HbA1c for diabetes (Figure 4a) and prediabetes (Figure 4b), respectively. For diabetes, the AUC was 0.8368 (95% confidence interval [CI] 0.828–0.883) for FPG, 0.933 (95% CI 0.9198–0.9462) for 2 h-PPG and 0.8064 (95% CI 0.7886–0.8241) for HbA1c. For prediabetes, the AUC was 0.8022 (95% CI 0.7905–0.8140) for FPG, 0.9282 (95% CI 0.9189–0.9356) for 2 h-PPG and 0.6895 (95% CI 0.6759–0.7032) for HbA1c. Our data clearly showed that the 2 h-PPG AUC values were the best indicators for both diabetes and prediabetes identifications.

In the present study, we also explored the optimal cut-off for HbA1c in screening diabetes and prediabetes. We investigated the sensitivity, specificity, Youden index, positive predictive value, and negative predictive value for identifying diabetes and prediabetes with different HbA1c thresholds. As shown in Supplemental Table 1, when the thresholds increased, the sensitivity decreased and the specificity increased. An HbA1c threshold of 6.3% showed a moderate sensitivity of 66.97% (95% CI 64.01–69.93%) and a specificity of 81.02% (95% CI 79.39–82.65%) for detecting diabetes; however, a high Youden index was achieved (0.4799, 95% CI 0.4461–0.5137). In contrast, an HbA1c threshold of 5.8% showed a moderate sensitivity of 64.59% (95% CI 62.61–66.57%) and a specificity of 64.27%
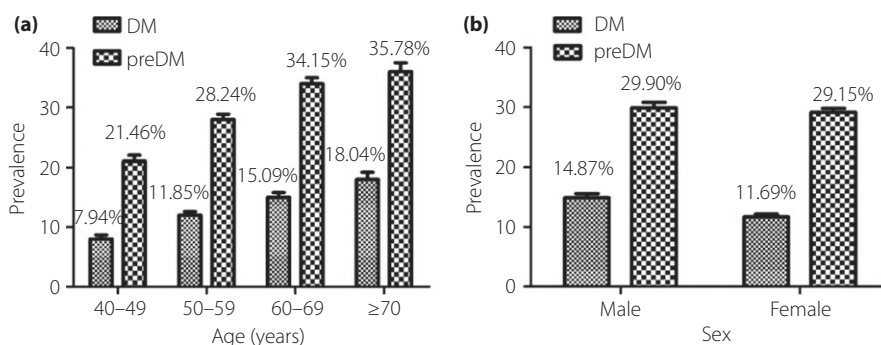

Figure 1 | (a) The prevalence of undiagnosed diabetes (DM) and prediabetes (preDM) by age. (b) The prevalence of undiagnosed diabetes and prediabetes among the male and female population.
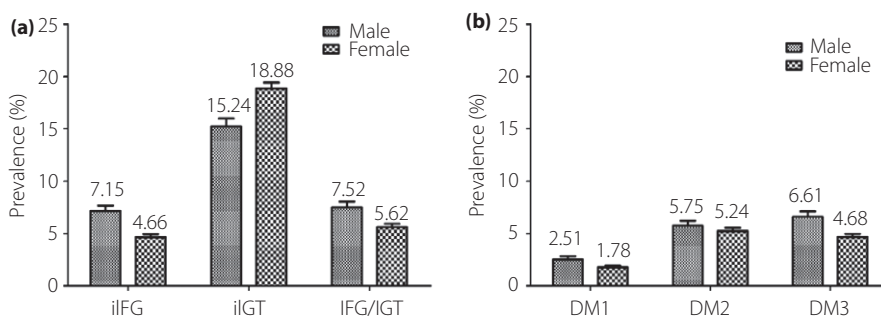

Figure 2 | (a) The prevalence of three kinds of impaired glucose regulation in the male and female population. (b) The prevalence of three types of diabetes in the male and female population. DM1, type 1 diabetes mellitus; DM2, type 2 diabetes mellitus; DM3, type 3 diabetes mellitus; IFG, impaired fasting glucose; iIFG, isolated impaired fasting glucose; iIGT, isolated impaired glucose tolerance.
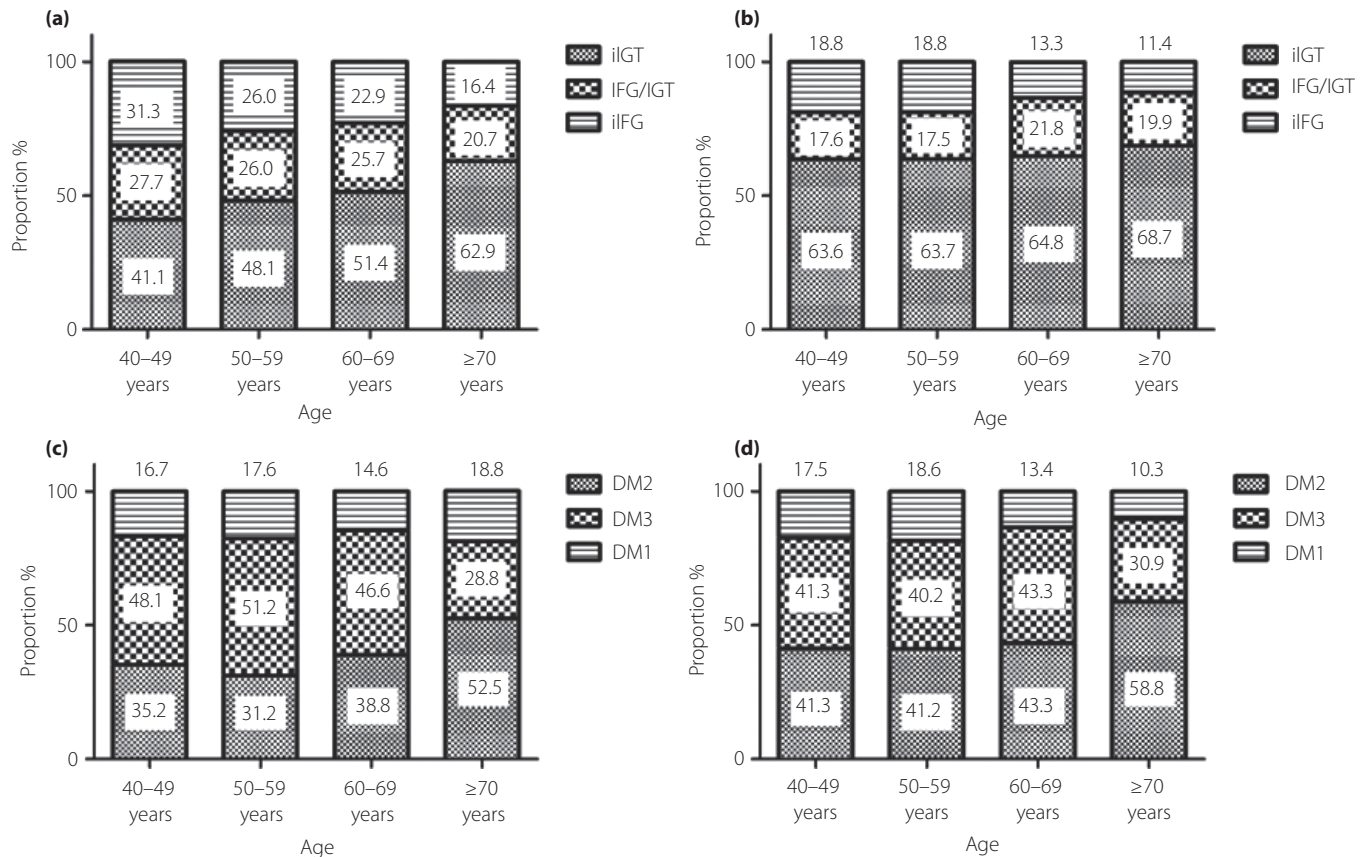
Figure 3 | (a) The proportion of three kinds of impaired glucose regulation in the male population in different age groups. (b) The proportion of three kinds of impaired glucose regulation in the female population in different age groups. (c) The proportion of three types of diabetes in the male population in different age groups. (d) The proportion of three types of diabetes in the male population in different age groups. DM1, type 1 diabetes mellitus; DM2, type 2 diabetes mellitus; DM3, type 3 diabetes mellitus; IFG, impaired fasting glucose; iIFG, isolated impaired fasting glucose; iIGT, isolated impaired glucose tolerance.

(95% CI 62.86–65.68%) for detecting prediabetes, whereas a high Youden index (0.2886, 95% CI 0.2642–0.313) was obtained (Supplemental Table 2). According to a previous study[24], we considered HbA1c thresholds of 6.3% (45 mmol/mol) and 5.8% (40 mmol/mol) as optimal cut-off values to screen diabetes and prediabetes, respectively.

DISCUSSION

FPG, 2 h-PPG, and HbA1c measurements are the most common methods to screen or diagnose diabetes and prediabetes. Many researchers believe that the 2 h-PPG test is time-consuming and limited by poor reproducibility; therefore, it is not a popular glucose screening method. However, a previous study by Qiao et al. has shown that in Chinese women over the age of 40 years, the 2 h-PPG level is significantly increased[25]. Another study by Louis et al.[26] has suggested that the elevated 2 h-PPG level is mainly manifested in the early stages of type 2 diabetes. Some studies have shown that 2 h-PPG, similar to HbA1c, is also an important predictor of risk for cardiovascular events and all-cause mortality[27]. Therefore, regular monitoring

of 2 h-PPG is very critical in the early detection and prevention of type 2 diabetes and its chronic complications.

In the present study, we carried out three different measurements including FPG, 2 h-PPG and HbA1c, and evaluated each method by statistical comparisons, in which the WHO 1999 standards were chosen as the gold standard. The cut-off points for FPG and 2 h-PPG in the diagnosis of diabetes and prediabetes using the WHO 1999 standards were recommended by both the 2010 and 2013 editions of the Chinese Guidelines for T2DM[15,28], which showed cost-effectiveness in the prevention and detection of type 2 diabetes in China. We compared the area under the ROC curve and found that 2 h-PPG had the highest AUC in the screening of diabetes, followed by FPG and HbA1c. It is worth noting that our AUC value for HbA1c was 0.8064 (95% CI 0.7886–0.8241), which is comparable with the previously reported value of 0.856 (95% CI 0.828–0.883) for people aged older than 20 years[29]. In screening for prediabetes, 2 h-PPG has an AUC value >0.9, suggesting a high diagnostic value, followed by FPG and HbA1c with values between 0.7–0.9 and <0.7, respectively. The AUC of HbA1c was also similar
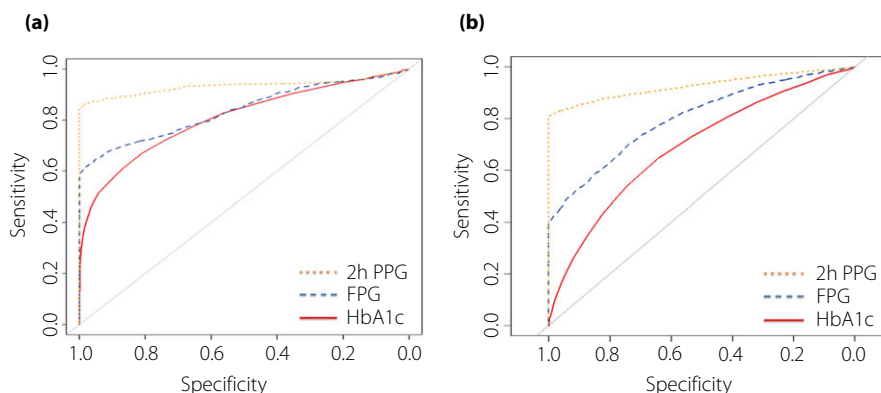
Figure 4 | Receiver operating characteristic curves of fasting plasma glucose (FPG), 2-h postload plasma glucose (2 h-PPG) and glycosylated hemoglobin (HbA1c) in screening (a) undiagnosed diabetes and (b) prediabetes from all participants. For diabetes, the area under the curve (AUC) of FPG was 0.8368 (95% confidence interval [CI] 0.828–0.883), the AUC of 2 h-PPG was 0.933 (95% CI 0.9198–0.9462), which was the largest, and the AUC of HbA1c was 0.8064 (95% CI 0.7886–0.8241). For prediabetes, the AUC of FPG was 0.8022 (95% CI 0.7905–0.8140), the AUC of 2 h-PPG was 0.9282 (95% CI 0.9189–0.9356), which was the largest, and the AUC of HbA1c was 0.6895 (95% CI 0.6759–0.7032).

to the previously reported values of 0.69 (European Caucasians) and 0.72 (South Asians) for people aged 40–75 years in a multi-ethnic cohort study in Great Britain[30]. In summary, 2 h-PPG is the best method to screen for diabetes and prediabetes.

In the present study, we found that the proportion of participants with abnormal 2 h-PPG levels was relatively high. If we did not carry out the 2 h-PPG measurement, we would miss 23% of iIGT patients and 3% of diabetes patients in those with normal fasting blood glucose levels; and we would miss 43% of iIGT patients and 19% of diabetes patients in those with iIFG. Thus, the sensitivity of the 2 h-PPG measurement in screening diabetes and prediabetes was higher than that of the FPG measurement. Although the Diabetes Epidemiology: Collaborative Analysis of Diagnostic Criteria in Europe study[25] reported that the increased prevalence of undiagnosed diabetes and prediabetes was mainly a result of the large increase of 2 h-PPG rather than FPG in an elderly European population, which showed that the proportion of isolated postload hyperglycemia was higher than that of isolated fasting hyperglycemia among those aged older than 60 years, we found that, in the present study, this happened among all participants aged older than 40 years. Thus, we concluded that the adult Chinese population was more prone to suffering postload hyperglycemia than European adults, showing an ethnic difference. This observation further emphasizes the importance and necessity of measuring 2 h-PPG levels in Chinese adults.

Our current study identified that many people in different age groups were newly diagnosed with diabetes and prediabetes, suggesting that the undiagnosed cases were possibly a result of the limitation of the detection methods. Generally, men have a higher prevalence of diabetes and prediabetes than women, which might be associated with higher caloric intake, and exposure to smoking, alcohol, stress and other risk factors[4,31]. We also found that people with dysglycemia had a higher age distribution, body mass index, waist circumference, waist-to-hip

circumference, blood pressure and family history of diabetes when compared with people with normal glucose levels (Supplemental Table 3). This observation is in line with previous studies[4,17,32,33]. Therefore, elderly people with a family history of diabetes, obesity, and hypertension should pay more attention to 2 h-PPG screening to get an early diagnosis and interventions to prevent diabetes.

So far, there are some controversies regarding the cut-off points of HbA1c for the diagnosis of diabetes and prediabetes. Both the ADA[12] and WHO[11] guidelines recommended HbA1c ≥6.5% as a diagnostic cut-off point for diabetes; and the ADA recommended HbA1c between 5.7% and 6.4% for prediabetes. However, the WHO did not suggest a clear HbA1c cut-off value for prediabetes. Interestingly, a number of studies have shown that the correlation between HbA1c values and blood glucose levels shows a racial difference; therefore, the aforementioned recommended HbA1c cut-off points by the ADA and WHO might not be optimal for the Chinese population[16,30]. In the present study, we evaluated different HbA1c cut-off points in screening diabetes and prediabetes by examining the sensitivity, specificity, and Youden index. The present results suggested an optimal HbA1c cut-off point of 6.3% in screening diabetes, consistent with a previous study[29]. We also proposed an ideal HbA1c cut-off point of 5.8% in screening prediabetes. To the best of our knowledge, there are no reports on the HbA1c cut-off point for the diagnosis of prediabetes using a large sample pool in China. The present study will greatly advance our understanding of the importance of the HbA1c cut-off point, and increase the diagnosis of diabetes and prediabetes in a Chinese population. However, there are some limitations for its use in China. First of all, standardization of HbA1c has not been used widely in the laboratories of Chinese hospitals. Although the measurement of HbA1c is a stable method for screening diabetes and prediabetes, based on the results of the present study, HbA1c sensitivity is somewhat lower and the cost of

HbA1c detection is somewhat higher, which might restrict its application in China.

In summary, the population of the present study from Changchun City, whether they had diabetes or prediabetes, had more abnormal 2 h-PPG levels compared with FPG levels, which might indirectly reflect a decreased insulin secretion from pancreatic islet β-cells and different diet compositions in the Chinese population. Islet β-cell function, insulin resistance and glucose spectral characteristics in different ethnic populations require further study. Based on the present study, the 2 h-PPG measurement is the best method to screen for diabetes and prediabetes.

We should mention that there are some limitations in the present study, such as an inadequate sample size for the male participants, which might result in a biased analysis. Additionally, because of the large overall sample size, we were unable to retest and confirm blood glucose abnormalities or investigate islet function and insulin resistance, which would be useful to assess the correlation between FPG, 2 h-PPG or HbA1c and islet function or insulin resistance. The gold standard for determining ideal cut-off points for screening methods of diabetes should be the incidence of diabetic retinopathy. Unfortunately, the present study, as a cross-sectional study, only evaluated the sensitivity and specificity of the various methods in screening for diabetes and prediabetes, without evaluating the ability of each method to predict the chronic complications of diabetes, such as diabetic retinopathy. Future studies including a follow-up survey and investigation will provide more valuable conclusions. Despite its limitations, our study provided reliable evidence for choosing a screening method for diabetes and prediabetes in Chinese or even an Asian population. Although there was a previous study by Bao *et al.*[29] reporting an HbA1c cut-off point for screening diabetes, the present study for the first time showed an HbA1c cut-off point for screening prediabetes in a general Chinese population by a large randomized observational study.

In conclusion, the 2-h post-load plasma glucose measurement is a necessary and cost-effective method for screening diabetes and prediabetes in China. HbA1c ≥6.3% (45 mmol/mol) and between 5.8% and 6.2% (40–44 mmol/mol) are the optimal cut-off values for the diagnosis of diabetes and prediabetes, respectively, in a Chinese population.

ACKNOWLEDGMENTS

DISCLOSURE

The authors declare no conflict of interest.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Table S1 | Sensitivity, specificity, Youden index, positive and negative predictive value for detecting diabetes.

Table S2 | Sensitivity, specificity, Youden index, positive and negative predictive value for detecting prediabetes.

Table S3 | Additional clinical characteristics of the participants.