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Original Article

Awareness and intervention status of prediabetes among Chinese adults: implications from a community-based investigation

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Abstract: With the rapid changes in lifestyle of China, the prevalence of diabetes and prediabetes is increasing. This study aims to evaluate the prevalence of prediabetes and study the disease awareness of prediabetes in a Southern China community. Furthermore, it also aimed to investigate the intervention status of lifestyle changes for prediabetes prevention. 881 adults without diabetes mellitus were recruited from the Suzhou community of China in 2012-2013. Self-report questionnaires including demographics, Disease Awareness Scale, Willingness on Lifestyle Changes for Prediabetes Cure Scale were collected. The results showed that 16.8% were in prediabetes, and 38.5% of them knew they had it. Young age, non-smoking, high education level, low BMI, and receiving provider advice were found with less possibility to have prediabetes in Chinese adults. Less than a third of those reported with the knowledge of that pre-diabetes is a risk factor of developing Type 2 diabetes mellitus (T2DM) and cardiovascular disease. Less a half of the population with prediabetes may take steps in lifestyle changes for pre-diabetes prevention. It is necessary to call for action on the improvement of disease awareness and promotion of healthy behaviors to prevent the prevalence of prediabetes and diabetes in Chinese adults.

Keywords: Pre-diabetes, awareness, behaviors, community

Introduction

Prediabetes is an evitable health condition with higher blood sugar level than normal but yet to be diagnosed as diabetes. It was also called as "borderline diabetes" and has 3 types of state, including impaired fasting glucose (IFG), impaired glucose tolerance (IGT), and IFG combined with IGT [1, 2]. Prediabetes is strongly associated with an increased risk of developing Type 2 diabetes and cardiovascular diseases [3]. People with prediabetes are likely to progress to diabetes within ten years or less, if no timely intervention or treatment is taken [4].

Prevalence of prediabetes and diabetes is increasing worldwide. The estimated prevalence of prediabetes and diabetes has reached an alert status in Chinese adults [5]. Based on the documented statistic information from China and United States, the diabetes rate of Chinese adults is currently higher than that of American, 11.6% vs 11.3% [5, 6]. Accordingly, China, housing the largest population of diabetes (approximately 113.9 million), is going to carry this huge burden on its public health system, and thus needs to spend massive efforts on diabetes prevention to keep sustainable development. Prediabetes can be easily identified by widely available clinic assessments, such as impaired fasting glucose (IFG) test, impaired glucose tolerance (IGT) test or glycated hemoglobin A1c(HbA1c) test [7, 8]. It is also well known that diabetes can be prevented or delayed in adults with prediabetes through feasible interventions on lifestyle, including moderate-intensity exercise, dietary restriction, and reasonable weight loss [7-9].

Shortage in the awareness of their conditions among prediabetes adults may have resulted in the loss of best opportunity to prevent Type 2 diabetes mellitus. Linda S [10] and colleagues showed that only 7.3% American adults with

prediabetes are aware of it. However, the statistic information on awareness of prediabetes and intervention status for Chinese adults is still missing. Herein, through a community-based study, we investigated the awareness of Chinese adults with prediabetes on the disease, analyzed the association factors and intervention status of prediabetes among Chinese adults. In the meanwhile, we also provided the regional prevalence data of prediabetes among Chinese adults in Suzhou community.

Subjects, materials and methods

Study participants

This study was conducted between Jan 2012 and May 2013, and involved 881 adults aged ≥ 20 years without being diagnosed as diabetes previously in the Suzhou community of China. In the examination, 148 were newly diagnosed prediabetes. All those 148 participants conform to the inclusive criterion (100%) with an age range of 21-78 years (mean = 52.15 ± 6.29 years). The participants newly diagnosed as prediabetes in our blood glucose test were assigned to complete the whole process of this investigation.

Inclusive criterion and exclusive criterion

The diagnostic standard of prediabetes was applied accordingly to Diabetes Prevention and Cure Guideline of China 2010 [1]. Subjects with a history of diabetes and pregnant women were excluded from this study. Participants with medical conditions, including congestive heart failure, coronary heart disease, angina, heart attack, stroke and other serious body diseases, were also excluded. And all of them have a clear conscious and without psychiatric history.

Ethics and consent

Ethical approval was received from the Human Research Ethics Committee of the appropriate institution. When accessing the online survey, potential participants were first provided with an introduction outlining the aims of the study. Implied consent was assumed if potential participants proceeded past this screen. Participants were free to discontinue their participation at any time. All data collected were de-identified prior to analysis.

Prediabetes screening

Participants were instructed to maintain the physical activity and diet as their usual lifestyles for at least 3 days prior to the laboratory examinations, including fasting plasma glucose test (FPGT) and oral glucose tolerance test (OGTT). After at least 10 hours of overnight fasting, a venous blood specimen was drawn from each individual as fasting blood samples. And the blood samples were stored at -80°C for subsequent analysis of blood glucose (mmol/L). The subjects with fasting plasma glucose ≥ 7.0 mmol/L (126 mg/dL) are waived from the OGTT, who were directly classified as diabetes. Before the OGTT, the measurement of 2-hour plasma glucose, blood samples of participants with FPG ≤ 6.9 mmol/L (125 mg/dL) were drawn in 120 minutes after taking a standard 75-g glucose solution. Through the two examinations, prediabetes were diagnosed with 3 types: ① IFG group with plasma glucose higher than 6.1 mmol/L (110 mg/dL) but ≤ 6.9 mmol/L (125 mg/dL), and 2-hour OGTT < 11.1 mmol/L (199 mg/dL); ② IGT group with 2-hour OGTT > 7.8 mmol/L (140 mg/dL) but < 11.1 mmol/L (199 mg/dL), and PFGT ≤ 6.9 mmol/L (125 mg/dL); ③ IFG combined with IGT.

Data collection

All participants with prediabetes were asked to complete a self-reported questionnaire under the instruction of trained staff. We termed the questionnaire as Awareness and Lifestyle Questionnaire in Prediabetes (ALQP), which was designed to obtain participant information on demographic variation, disease awareness and plans on lifestyle changes. The questionnaire included questions about age, height, body weight, smoking, the family history of diabetes, blood pressure, whether received advice from healthcare providers, education level and occupations of the family member (whether related to medicine). Cigarette smoking was defined as having smoked at least 100 cigarettes in one's lifetime. Blood pressure, body weight, height were measured with the use of standard methods, as described previously. Body mess index (BMI) was calculated as weight in kilogram divided by height in meters squared. Education level was categorized as primary school or below, high school, and college or above.

Table 1. Prevalence of pre-diabetes among Chinese adults of Suzhou community in 2012-2013 (n = 881)

Glucose State	Number	Percentage (%)
NGT	669	75.9
Pre-diabetes		
IGT	54	6.1
IFG	60	6.8
IGT + IFG	34	3.9
Diabetes	64	7.3
Total	881	100.0

Note: NGT: Normal glucose tolerant; IGT: Impaired glucose tolerance; IFG: Impaired fasting glucose.

All study investigators and staff members successfully completed a training program that tutored them to be familiar with the aim of the study, the involved tools and methods. In the training program, interviewers were taught with detailed instructions on the administration of the study questionnaire. Clinical staff members were trained to measure blood pressure, draw the blood sample and obtain anthropometric measurements using the standard protocol [11].

Assessment of the awareness and behaviors among Chinese adults with prediabetes

Seven questions were asked in order to assess the awareness of prediabetes among the participants with prediabetes: ① Do you know about prediabetes? ② Do you know about impaired fasting glucose? ③ Do you know about impaired glucose tolerance? ④ Do you know about borderline diabetes? ⑤ Do you know your plasma glucose levels are higher than normal? ⑥ Do you know prediabetes is a leading risk of Type 2 diabetes mellitus? ⑦ Do you known prediabetes is a risk of cardiovascular disease? The answers for all the seven questions are set up as " Yes" or "No". Par-Oticipants selected "Yes" or "No" based on their own knowledge and were encouraged to give only one answer to each question.

In order to investigate their willingness on lifestyle changes to prevent diabetes, three questions were asked from all the participants with prediabetes: ① To control weight. ② To increase physical activity. ③ To reduce fat/calories in diet. Three options to answer the above problems were provided as "Yes", "No", and "Ongoing in two years", with which also only one can be selected by the participants. All 148 participants accomplished the questionnaires successfully under the instruction of our trained staff.

Statistic analysis

The data were analyzed within the SPSS statistical package, version 16.0. Data are presented as the percentage. Chi square test was used to assess the differences of general data between person with prediabetes and normal states. Multiple logistic regression analysis was performed to detect the risk factors of prediabetes. Data for pre-diabetes people on disease awareness and wiliness to change lifestyles were summarized by calculating the percentages. In all analyses, $P < 0.05$ was used to determine statistical significance. All *P* values are three-tailed and have not been adjusted for multiple testing.

Results

The prevalence data of prediabetes among Chinese adults in Suzhou community was presented in **Table 1**. About 16.8% of Chinese adults in Suzhou community are prediabetes. Providing the data detailed in types, the prevalence of IGT is estimated as 6.1%, with IFG as 6.8% and IFG combine with IGT as 3.9% in the Suzhou community of China. Surprisingly, the regional prevalence rate for prediabetes among Chinese adults in Suzhou is three fold less than the average rate for overall Chinese adults, 50.1%, reported by the latest study based on a nationally recruited sample of Chinese adults [5].

The demographic data of prediabetes and normal status were shown in **Table 2**. 84.8% of Chinese adults having prediabetes in Suzhou community are with education level as high school or below. The proportion of hypertension, smoking and overweight for people with prediaberes were 64.9%, 60.1%, 46.6%, respectively. Consistent with other's results [12], we also identified smoking is remarkably associated with prediabetes prevalence. Overall, Chinese adults as the elder age, low education level, overweight or obese are positively linked with prediabtes in Suzhou. Only 17.6% of prediabetes people in this community received health advice from healthcare providers.

Table 2. General Data in pre-diabetes and normal glycemia population of China (n = 817)

General data	Pre-diabetes (n = 148)%	Normal glycemia (n = 669)%	*p-value*
Gender			
male	44.6	46.5	
female	55.4	53.5	0.744
Age			
20-39	24.3	49.4	
40-59	45.9	38.9	
> 60	29.8	11.7	0.000
Education			
College or above	16.2	52.2	
High school	60.1	32.9	
Primary school and blow	23.7	14.9	0.000
Diabetes History of family			
Yes	45.3	38.3	
No	54.7	61.7	0.001
Smoking			
Yes	60.1	41.3	
No	38.9	58.7	0.000
Weight			
Normal	25.7	47.8	
Overweight	46.6	40.1	
Obesity	27.7	12.1	
Mean BMI	23.8	20.6	0.000
Hypertention			
Yes	35.1	18.7	
No	64.9	81.3	0.000
Received advice from healthcare providers			
Yes	17.6	11.2	
No	82.4	88.8	0.047
Occupation of family members (related to medicine)			
Yes	12.2	8.2	
No	87.8	91.8	0.173

Note: BMI: Body Mass Index, the criteria of BMI is according to the Ministry of Public Health of China; Hypertention: Systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg, or use of antihypertensive medication.

Table 3. Risk factors for pre-diabetes (n = 881)

Variable	*p-value*
Gender	.009
Age	.000
Education level	.000
Family history of diabetes	.115
Hypertension	.000
Access to advice of healthcare providers	.031
Occupation of family member	.046
BMI	.000
Smoking	.000

In order to explore the risk factors of pre-diabetes in the Suzhou population, multiple logistic regression analysis was conducted. As shown in **Table 3**, gender, age, education level, hypertension, access to provider' advice, BMI and smoking were all significantly associated with pre-diabetes. Women, elders, smokers, overweight population, people with education of high school, without access to provider's advice or without relatives working in health care system were at high risk of pre-diabetes.

The awareness of prediabetes in Chinese adults with prediabetes of Suzhou community was presented in **Table 4**. Less a third of people with prediabetes reported themselves having heard of prediabetes or borderline diabetes, 21.6% and 16.9% respectively. There are very few with the detailed knowledge of the prediabetes, 8.1% for IFG and 4.1% for IGT. About 38.5% of Chinese adults with prediabetes in this community knew their own condition. Less than a quarter of people in this community know the risks of prediabtes to develop chronic diseases, such as type 2 diabetes and cardiovascular disease.

The intervention status of Chinese adults with prediabetes in Suzhou community was shown in **Table 5**. Three prediabetes intervention behaviors, the effectiveness of which had been confirmed in other study [10], were suggested to our participants. The examination resulted in a conclusion that less than half of those people with prediabetes are willing to take steps to reduce or reverse the disease upon knowing their condition.

Discussion

In current study, we investigated the prevalence of prediabetes among Chinese adults in Suzhou

Table 4. Disease Awareness of Pre-diabetes in Suzhou Community of China (n = 148)

Variables	Yes (%)	No (%)	Total (%)	t	*p*-value
Do you know about pre-diabetes	21.6	78.4	100	52.536	0.000
Do you know about impaired fasting glucose	8.1	90.9	100	85.235	0.000
Do you know about impaired glucose tolerance	4.1	95.9	100	120.458	0.000
Do you know about borderline diabetes	16.9	83.1	100	59.252	0.000
Did you know your plasma glucose levels are higher than normal	38.5	61.5	100	40.234	0.000
Did you know pre-diabetes is a leading risk of Type 2 diabetes mellitus	28.4	71.6	100	46.155	0.000
Did you know pre-diabetes is a risk of cardiovascular disease	18.9	80.1	100	57.344	0.000

Table 5. Lifestyle intervention status of Chinese adults with pre-diabetes in Suzhou communities (n = 148)

Variables	Yes (%)	No (%)	Ongoing in 2 years (%)	t	*p*-value
To control body weight	28.4	45.9	25.7	32.558	0.000
To increase physical activity	41.9	36.5	21.6	28.273	0.000
To reduce fat/calories in diet	35.1	28.4	36.5	28.850	0.000

community, the awareness and the intervention status of prediabetes.

Our results indicate that prediabetes has reached epidemic proportion among the adult population in Suzhou of China. About 2.01 million adults 20 years of age or older have prediabetes, based the prevalence of prediabetes and the total population of Suzhou. The diagnostic criteria of prediabetes in this study were applied according to Diabetes Prevention and Cure Guideline of China [1]. Based on the guideline, fasting plasma glucose levels of 6.1 to 6.9 mmol/L (110 to 125 mg/dL) are classified as IFG. However, the IFG diagnostic criterion of American Diabetes Association (ADA) is 5.6 to 6.9 mmol/L (100 to 125 mg/dL) [13]. If the IFG diagnostic criteria were applied with ADA standards, it is possible that we may have more prediabetes identified in our evaluation.

Increase the disease awareness in prediabetic population. The estimate prevalence of prediabetes among overall Chinese adults was recently reported as 50.1% [5], which raised worldwide attention [14] and also led us to investigate the regional prevalence and awareness of prediabetes in Suzhou community. **Table 1** showed that 16.8% of Chinese adults in Suzhou community have prediabetes, but only about 38.5% knew about that they had the disease (**Table 4**). The prevalence of prediabetes among Chinese adults in Suzhou community is much less than the result of the above, although we did not combine the glycated hemoglobin A1c (HbA_{1c}) test into our criteria to diagnose prediabetes as they did. The awareness of diabetes was explored in the latest study with the awareness definition as the percentage of individuals who knew their history of physician-diagnosed diabetes among all patients with diabetes [5]. It is known that diabetes is an inevitable health condition, while prediabetes is feasible to be reversed or delayed on the progression to Type 2 diabetes mellitus [3, 15]. Without intervention in time, 33%-65% IFG or IGF patients will turn onto overt Type 2 diabetes mellitus [16]. Okosun and colleagues reported that people knowing their poor glycemia condition (prediabetes) prefer to adopt lifestyle interventions for delaying and preventing Type 2 diabetes mellitus, as well as its associated complication [17]. We investigated the awareness of prediabetes among all newly diagnosed prediabetic persons in our study, which is more useful alerting information to make action in diabetes prevention among Chinese adults.

Control the risk factors of prediabetes in life. Prediabetes is a leading risk factor for the development of overt Type 2 diabetes mellitus and cardiovascular disease [18, 19]. Significant differences were identified between Chinese adults with prediabetic and normal conditions, including age, gender, education level, smoking, weight, and advice of healthcare provider (**Table 2**). Older age, female, education level of high school, smoking, increased BMI, were positively associated with prediabetes (**Table 3**). Although it is not possible to change some of the related risk factors, such as age, gender and the diabetes history of family, most of oth-

ers are feasible to modify to reverse or prevent prediabetes, including smoking, education level, weight and receiving advice from healthcare provider. Therefore, the Chinese public health administrators or healthcare providers can reduce the prevalence of prediabetes by providing more advice on the disease prevention and promoting the healthy lifestyle behaviors.

Increase knowledge of positive lifestyle interventions to prevent and delay the progression of prediabccetes. Randomized clinical trials indicate that positive lifestyle interventions involving diet restriction and moderate exercise can reduce the risk of diabetes by 58% over three years among people with prediabetes [4, 20, 21]. However, the intervention status or wiliness for changes among Chinese adults with prediabetes in Suzhou community seems not gratifying, with less than half of them willing to take actions in prediabetes reduction (**Table 5**). Based on our evaluation, we propose three possibilities for persons with prediabetes without willing to adopt lifestyle interventions: ① most residents in Suzhou are short of knowledge on prediabetes; ② persons with prediabetes underestimate their condition state, i.e., people thought they were healthy unless being diagnosed as the inevitable diabetes; ③ people with prediabetes do not know what are the effective lifestyle interventions.

Study strength and limitation

The major strength of the present study is that the data were representative of the Chinese adult population, and the diagnosis criteria of prediabetes were selected for Chinese adults from the Diabetes Prevention and Cure Guideline of China. The biological risk factor data were collected using standardized laboratory and physical measurements. However, there are still some limitations. First, more participants were female. Second, the questionnaire about disease awareness and lifestyle intervention was self-reported. Third, the number of participants might not be very big owing to the shortage of research funding. Finally, a number of important data were not measured, such as HbA1c, total cholesterol, HDL, and LDL.

Conclusion

The prevalence rate of prediabetes among Chinese adults in Suzhou community is almost three fold less than that reported in the latest study, as 16.8% verses 50.1%. However, enormous efforts are needed to promote awareness of prediabetes in Suzhou community or even overall China, since only about one third of them know their own health condition and prediabetes risks. Instructions and advice on effective lifestyle interventions for prediabetes or diabetes prevention are demanded to end the rapid rise of prediabetes prevalence in Chinese adults.

Disclosure of conflict of interest

None.

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