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Follow-up of blood glucose distribution characteristics in a health examination population in Chengdu from 2010 to 2016

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Abstract

The worldwide prevalence and incidence of diabetes and obesity are increasing in pandemic proportions. Thus, regular health examination is an important way for early detection of diabetes and glucose intolerance. The present study aims to detect the blood glucose distribution characteristics of the participants in the Health Examination Center at West China Hospital, Sichuan University from 2010 to 2016.

A prospective cohort included 9168 Chinese participants, aged 18 years or more, who had available information on fasting blood glucose concentrations at the start of the study (2010). Examination surveys were conducted every year from 2010 to 2016. Cases having serum level of fasting blood glucose between 2.2 and 6.1 mmol/L were considered as normality, while serum level of fasting blood glucose $<$ 2.2 or higher than 6.2 mmol/L were considered as abnormality.

The percentage of participants having normal level of glucose was gradually reduced both in males and females from 2010 to 2016, by which the percentage of males having normal level of glucose was significantly lower than that in females. Moreover, the mean level of glucose was significantly increased from 2010 to 2016 both in males and females overall, and the mean level of glucose was higher in males compared with that in females every year. Furthermore, we showed that the level of glucose was gradually increased year by year in each age group, and the level of glucose was higher in aged cases compared with the young population.

The study population in the current study showed higher levels of glucose with ages increasing, and males indicated higher expression of glucose than that in females. Some preventive action may be adopted early and more attention can be paid to this health-examination population.

Abbreviations: CD = cognitive decline, DPS = diabetes prevention study, HOMA = homeostasis model assessment for insulin resistance, IFG = impaired fasting glucose, IGR = impaired glucose regulation, IGT = impaired glucose tolerance, T2DM = type 2 diabetes mellitus.

Keywords: blood glucose, cohort study, epidemiology, trends

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1. Introduction

The worldwide prevalence and incidence of chronic non-communicable diseases, particularly diabetes and obesity, are gradually elevated in pandemic proportions in recent years.[1] In 2015, the global prevalence of diabetes may be 415 million adults, with 12% of global expenditure (US$ 673 billion) on health cost for diabetes care alone.[2] In the United States in 2011 and 2012, 12% to 14% of adults had type 2 diabetes mellitus (T2DM) and 38% had prediabetes.[3] Prediabetes is even more common among those aged $\geq$ 65 in the United States, with a prevalence of 50%.[4] This phenomenon is more severe in south and southeast Asian countries, which are thought to represent a large burden of the global incidence of diabetes, particularly for China because of large population is growing, aging, and urbanizing. Steady increased incidence of T2DM correlated with adverse eating habits, obesity, and inadequate physical activity led to an exponential rise in diabetes-related complications morbidity worldwide recently.[5] This trend is expected to upregulate further with the improvement in life expectancy from advancements in science, technology, and healthcare resources that lead to a strongly rise in the proportion of older individuals in the global population with higher prevalence of T2DM and obesity. World Health Organization's current estimate of 900 million people aged $\geq$ 60 years (12% of global population in 2015) is expected to cross 2 billion by 2050 (22% of world population), with 80% of these people in the low- and middle-income countries would catalyze the explosiveness of this alarming situation.[6]

Diabetes is a progressive disorder resulting in complications, which are broadly divided into small vessel or microvascular disease and large vessel or macrovascular disease. Microvascular complications affect the inner part of the eye—the retina known as diabetic retinopathy, the kidney termed as diabetic nephropathy, and the peripheral nerves termed as diabetic neuropathy. The macrovascular complications affect the heart, the brain, and the peripheral arteries termed as cardiovascular disease, cerebrovascular disease, and peripheral vascular disease, respectively.[7] Elevated blood levels of glucose in middle age may affect cognitive decline (CD). In a study of 833 participants with 20 years follow-up, mean fasting glycemia at baseline was significantly higher in moderate-severe CD subgroup than in the normal cognition subgroup. After adjustment of gender, age, and other metabolic components, higher fasting glycemia values both at baseline and 7 year's follow-up were associated with an increased risk of moderate-severe CD. Mean homeostasis model assessment for insulin resistance (HOMA) index value was significantly higher in the moderate-severe CD subgroup compared to the normal cognition subgroup at baseline, highlighting the indication to control blood glucose levels, regardless of a diagnosis of diabetes mellitus, as early as midlife for prevention of late-life dementia.[8] Since some of the complications of diabetes correlate with severe mortality, it is accepted that early detection, diagnosis of diabetes and take action to prevent diabetes development or its complications is of importance. Regular health examination is an important way for early detection of diabetes and glucose intolerance. In the present study, a total of 9168 participants were recruited in the Health Examination Center at West China Hospital, Sichuan University. We analyzed the fasting blood glucose from 2010 to 2016 every year for all of them, in order to reveal the blood glucose distribution characteristics among the health examination population.

2. Materials and methods

2.1. Study population

A number of 9168 participants were included in this prospective cohort study since 2010, selected from the Health Examination Center at West China Hospital, Sichuan University. Of them, 5453 were males and 3715 were females, aged than 18 years overall. From 2010 to 2016, all of the subjects agreed to participate every year and were enrolled after written informed consent was obtained, which was in accordance with the Declaration of Helsinki. Peripheral blood was collected from all participants. The corresponding protocol was approved by the Ethics of Research Committee of the West China Hospital, Sichuan University.

2.2. Collection of laboratory data and glucose measurement

Data about demographic, laboratory features were collected from hospital records or by questionnaire. Fasting blood samples were collected at baseline in 2010 and again in 2011, 2012, 2013, 2014, 2015, and 2016 every year from the antecubital vein after an 8- to 10-hour overnight fast in vacuum tubes containing ethylene diamine tetraacetic acid. Fasting blood glucose concentrations in each survey were examined with hexokinase method by Roche cobase 702. The same assay was used on all participants at baseline in 2010 and at each follow-up examination from 2011 to 2016. The coefficient of variation using blind quality control specimens was <2.0%. Serum level of fasting blood glucose between 2.2 and 6.1 mmol/L was considered as normality. On the contrary, serum level of fasting blood glucose < 2.2 or higher than 6.2 mmol/L was considered as abnormality.

2.3. Statistical analysis

All participant information and laboratory results were entered into a customized database, and then analyzed by the R 3.0 statistical software (Chinese Academy of Sciences, Beijing, China). Data are given as mean values ± standard deviation, and categorical variables are described as frequencies and percentages (%). The difference between percentages of males and females having serum glucose level higher than 6.2 mmol/L were compared using Chi squared. ANOVA analysis was used to detect the difference of glucose level from 2010 to 2016. To descript the level of fasting blood glucose, we noted the maximum, minimum, mean, and standard deviation. Analyses were all two-tailed and considered statistically significant when *P* value was <.05.

3. Results

3.1. Characteristics of the health examination population and the fasting blood glucose

The basic characteristics of participants recruited in this study in 2010 were listed in Table 1. A total of 9168 people were evaluated in this study since 2010, among which 5453 were males and 3715 were females (Table 2). Among this population, we found that the percentage of males and females having normal level of glucose was 89.36% and 95.34% in year 2010, respectively. When these participants followed-up for 6 years, we noted 85.00% and 93.54% of males and females having normal level of glucose up to 2016, respectively. Overall, the percentage of the participants having normal level of glucose was reduced from 2010 (91.97%) to 2016 (88.46%). Results indicated that the percentage of participants having normal level of glucose was gradually reduced both in males and females (Table 2).

In 2010, the mean level of glucose was 5.23 mmol/L overall. Up to 2016, the mean level was increased to 5.33 mmol/L (Table 3). ANOVA analysis indicated that the level of glucose during the 7

Table 1

Basic characteristics of participants in this study in 2010.

	Normal level of glucose	Abnormal level of glucose
Number	8415	753
Age, years	43.80 ± 13.51	44.15 ± 13.45
Women, %	42.25	37.55
Education		
Illiteracy/primary, %	5.51	7.18
High school, %	65.32	72.49
College or above, %	29.17	20.33
Body mass index, kg/m^2	21.31	23.85
Exercise 3002B; times/wk, %	20.95	22.54
Hypertension, %	31.25	38.29

Table 2

Characteristics of all the health examination population and the cases with normal level of fasting blood glucose (2010–2016).

Year	Cases with normal glucose (number, %)		
	Males (n=5453)	Females (n=3715)	Overall (n=9168)
2010	4873 (89.36)	3542 (95.34)	8415 (91.79)
2011	4811 (88.23)	3532 (95.07)	8343 (91.00)
2012	4791 (87.86)	3526 (94.91)	8317 (90.72)
2013	4644 (85.16)	3462 (93.19)	8106 (88.42)
2014	4593 (84.23)	3437 (92.52)	8030 (87.59)
2015	4566 (83.73)	3444 (92.71)	8010 (87.37)
2016	4635 (85.00)	3475 (93.54)	8110 (88.46)

years was significantly different ($F=53.18$, $P<.0001$). When the serum level of glucose in 2010 was defined as reference, we found that the serum level of glucose in 2011 was significantly higher than that in 2010 ($t=2.50$, $P=.0123$). Similarly, the level of glucose from 2012 to 2016 was higher than that in 2010, respectively (Table 3).

3.2. Distribution of glucose in participants having normal level of glucose

There were 4873 males and 3542 females showing with normal level of glucose in 2010. Up to 2016, the number of participants having normal glucose level was reduced both in males and females (Table 4). Similarly, the mean level of glucose was 5.05 mmol/L in males and 4.96 in females in 2010, respectively. Till 2016, the mean level of glucose was gradually increased both in males and females, respectively. When discussed the glucose level between 2011 and 2010, there was significant difference both in males and females ($P=.0107$, $P=.0018$). Similarly, the level of glucose in years 2013 to 2016 was higher than that in 2010 overall, respectively. Furthermore, the data indicated that the mean level of glucose was higher in males compared with that in females every year (Table 4).

Regarding the level of glucose among different ages, we divided the ages into 7 groups (group 1: 21–30 years, group 2: 31–40 years, group 3: 41–50 years, group 4: 51–60 years, group 5: 61–70 years, group 6: 71–80 years, group 7: higher than 80 years). As in Table 5, the mean level of glucose was increased from 4.77 mmol/L in year 2010 to 4.80 mmol/L in year 2016 in group 1. Similarly, the mean level of glucose was gradually increased from 2010 to 2016 in groups 2 to 6 overall. With respect to the 7th group, the mean level of glucose was gradually reduced from 2010 to 2016. When discussed the glucose level between 2011 and 2010 in group 1, there was significant difference ($P=.0084$). Similarly, the other 5 year's glucose level was higher than that in 2010, respectively. In addition, in group 2 to group 6, we also find increased level of glucose in years 2011 to 2016 when compared with year 2010 overall. These data suggested that the level of glucose was gradually increased year by year in each group, and the level of glucose was higher in aged cases compared with the young population every year overall, for instance, the mean level of glucose was 4.77 mmol/L in group 1, and the mean level was 5.39 mmol/L in group 7 in year 2010 (Table 5).

3.3. Characteristics of the participants having serum level of glucose higher than 6.2 mmol/L

According to the cases with higher level of glucose than 6.2 mmol/L, we found that the percentage was 9.54% among males, while the percentage was 4.06% among females in year 2010. However, the percentage was gradually increased and upregulated to 13.74% among males, 5.63% among females in year 2016 (Fig. 1). In addition, the percentage was significantly higher in males compared with that in females every year, respectively ($\chi^2=97.5176$, $P<.001$ for year 2010; $\chi^2=129.2938$, $P<.001$ for year 2011; $\chi^2=135.0435$, $P<.001$ for year 2012; $\chi^2=152.7914$, $P<.001$ for year 2013; $\chi^2=140.8335$, $P<.001$ for year 2014; $\chi^2=161.3171$, $P<.001$ for year 2015; $\chi^2=155.3001$, $P<.001$ for year 2016). To clearly discuss the percentage of abnormal glucose level among different ages, we also divided the ages into 7 groups (group 1: 21–30 years, group 2: 31–40 years, group 3: 41–50 years, group 4: 51–60 years, group 5: 61–70 years, group 6: 71–80 years, group 7: higher than 80 years). As in Figure 2, the difference of percentage of abnormal glucose level in each year among different groups was significant, respectively ($\chi^2=23.7174$, $P<.001$ for year 2010; $\chi^2=22.7244$, $P<.001$ for year 2011; $\chi^2=23.1835$, $P<.001$ for year 2012; $\chi^2=25.3483$, $P<.001$ for year 2013; $\chi^2=24.9287$, $P<.001$ for year 2014; $\chi^2=26.3785$, $P<.001$ for year 2015; $\chi^2=24.8731$, $P<.001$ for year 2016, Table S1-S6, http://links.lww.com/MD/C127). Groups 1 and 2 were lower than the other groups every year, and the percentage of abnormal glucose level in groups 3–8 was gradually increased year by year overall (Fig. 2).

4. Discussion

This is a follow-up study conducted on 9168 participants with health examination higher than 18 years old from Chengdu City in Sichuan province and the surrounding areas from 2010 to 2016. The present study discussed the serum level of fasting blood glucose both in males and females year by year. We found that the percentage of participants having normal level of glucose was gradually reduced both in males and females from 2010 to 2016, by which the percentage of males having normal level of glucose was significantly lower than that in females. Moreover, the mean

Table 3

Characteristics of fasting blood glucose among all the health examination population (2010–2016).

Year	Number	Minimum, mmol/L	Maximum, mmol/L	Mean, mmol/L	Standard deviation	*t*	*P* value
2010	9168	2.43	21.32	5.23	1.05	–	–
2011	9168	2.54	21.88	5.28	1.08	2.50	<.0123
2012	9168	3.49	20.88	5.26	1.08	1.40	.1620
2013	9168	3.70	19.62	5.40	1.12	9.49	<.0001
2014	9168	2.99	21.52	5.44	1.20	11.98	<.0001
2015	9168	3.33	22.94	5.45	1.27	12.50	<.0001
2016	9168	3.34	22.10	5.33	1.26	2.51	<.0001

Table 4

Characteristics of the cases with normal level of glucose in different sex.

Sex	Year	Number	Minimum, mmol/L	Maximum, mmol/L	Mean, mmol/L	Standard deviation	*t*	*P* value
Male	2010	4873	3.18	6.09	5.05	0.45	–	–
	2011	4811	3.29	6.09	5.08	0.45	2.55	.0107
	2012	4791	3.49	6.09	5.06	0.45	0.19	.8513
	2013	4644	3.70	6.09	5.15	0.43	10.14	<.0001
	2014	4593	2.99	6.09	5.15	0.44	10.60	<.0001
	2015	4566	3.33	6.09	5.13	0.45	8.27	<.0001
	2016	4635	3.48	6.09	5.03	0.46	−2.42	.0158
Female	2010	3542	2.43	6.09	4.96	0.41	–	–
	2011	3532	2.54	6.09	4.99	0.42	3.13	.0018
	2012	3526	3.58	6.09	4.96	0.41	0.16	.8756
	2013	3462	3.70	6.09	5.06	0.41	10.56	<.0001
	2014	3437	3.31	6.09	5.08	0.41	12.63	<.0001
	2015	3444	3.54	6.09	5.07	0.42	11.09	<.0001
	2016	3475	3.34	6.09	4.95	0.43	−0.73	.4684

Table 5

Characteristics of the cases with normal level of glucose in different ages.

Age	Year	Number	Minimum, mmol/L	Maximum, mmol/L	Mean, mmol/L	Standard deviation	*t*	*P* value
21–30	2010	187	3.68	6.00	4.77	0.41	–	–
	2011	188	3.88	5.89	4.88	0.39	2.65	.0084
	2012	188	4.06	6.06	4.81	0.36	1.04	.2975
	2013	187	4.01	6.09	4.90	0.35	3.26	.0012
	2014	186	4.02	5.94	4.94	0.38	4.05	<.0001
	2015	186	3.74	5.99	4.94	0.38	3.98	<.0001
	2016	187	3.67	5.76	4.80	0.37	0.64	.5212
31–40	2010	1901	3.34	6.09	4.90	0.40	–	–
	2011	1884	3.34	6.04	4.94	0.40	3.34	.0008
	2012	1889	3.62	6.09	4.91	0.40	0.99	.3235
	2013	1871	3.77	6.08	4.99	0.38	6.80	<.0001
	2014	1865	3.59	6.08	5.02	0.38	9.29	<.0001
	2015	1866	3.33	6.07	4.97	0.40	5.86	<.0001
	2016	1876	3.56	6.09	4.86	0.40	−2.61	.0090
41–50	2010	2779	2.43	6.09	4.97	0.42	–	–
	2011	2764	2.54	6.09	4.99	0.42	2.02	.0437
	2012	2767	3.49	6.09	4.97	0.43	0.20	.8419
	2013	2712	3.70	6.09	5.07	0.41	8.99	<.0001
	2014	2671	2.99	6.08	5.09	0.42	10.57	<.0001
	2015	2688	3.33	6.09	5.07	0.43	8.93	<.0001
	2016	2703	3.55	6.09	4.96	0.44	−0.78	.4368
51–60	2010	2139	3.18	6.09	5.06	0.43	–	–
	2011	2115	3.29	6.09	5.08	0.44	1.75	.0807
	2012	2101	3.66	6.09	5.06	0.45	−0.20	.8420
	2013	2032	3.70	6.09	5.17	0.44	8.44	<.0001
	2014	2027	3.71	6.09	5.18	0.43	8.81	<.0001
	2015	2008	3.54	6.09	5.17	0.44	8.37	<.0001
	2016	2031	3.34	6.09	5.07	0.46	0.61	.5395
61–70	2010	857	3.76	6.09	5.17	0.43	–	–
	2011	843	3.55	6.09	5.19	0.45	0.90	.3694
	2012	829	3.74	6.09	5.16	0.44	−0.35	.7249
	2013	806	3.96	6.08	5.28	0.41	5.22	<.0001
	2014	773	3.78	6.09	5.25	0.43	3.38	.0001
	2015	775	3.93	6.09	5.26	0.43	4.06	<.0001
	2016	795	3.98	6.09	5.15	0.42	−1.09	.2745
71–80	2010	435	3.39	6.07	5.29	0.45	–	–
	2011	433	3.91	6.09	5.27	0.43	−0.43	.6669
	2012	430	3.96	6.08	5.27	0.44	−0.56	.5731
	2013	402	3.80	6.09	5.36	0.40	2.49	.0129
	2014	406	3.93	6.09	5.34	0.42	1.86	.0636
	2015	387	3.60	6.09	5.32	0.43	1.17	.2430
	2016	407	3.66	6.09	5.24	0.46	−1.56	.1182
>80	2010	117	4.20	6.08	5.39	0.44	–	–
	2011	116	4.32	6.09	5.35	0.38	−0.66	.5093
	2012	113	4.11	6.09	5.29	0.43	−1.70	.0909
	2013	96	4.30	6.06	5.37	0.42	−0.34	.7308
	2014	102	4.16	6.07	5.28	0.44	−1.76	.0802
	2015	100	4.43	6.08	5.34	0.39	−0.84	.4018
	2016	111	4.04	6.09	5.27	0.47	−1.90	.0583

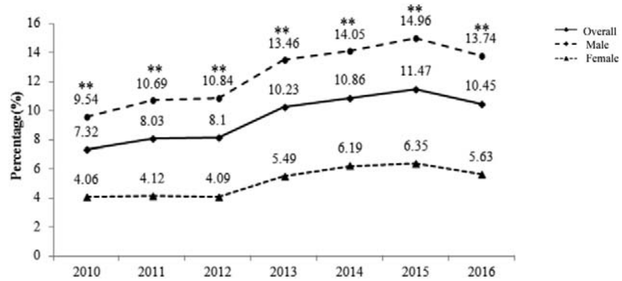

Figure 1. Trends of the percentage of cases with fasting blood glucose >6.2 mmol/L in different sex. Both males and females with fasting blood glucose >6.2 mmol/L were upregulated from 2010 to 2016 overall. The percentage of males with fasting blood glucose >6.2 mmol/L was higher than that in females every year ($^{**}P<.001$).

level of glucose was significantly increased from, 2010 to 2016 both in males and females overall, and the mean level of glucose was higher in males compared with that in females every year. Furthermore, we showed that the level of glucose was gradually increased year by year in each group, and the level of glucose was higher in aged cases compared with the young population. All these data suggested that participants with health examination in the current study were prone to higher glucose with ages increasing, and males showed higher expression of glucose than females.

Several studies reported a higher incidence of DM in men than women.[9–11] Habits such as alcohol consumption, smoking, increased age, and physical activity levels may lead to the elevation of DM in males.[12–14] In addition, it is accepted that life and job stress are much higher in males than in females in China; less attention has been paid to them, and an unhealthy lifestyle may also cause a rise in blood glucose. Therefore, it is possible that males may show higher expression of glucose than in females, similar to our findings.

In 2010, the Center for Disease Control estimated the incidence of diabetes to be 5.5, 15.6, and 13.1 cases per 1000 population in men aged 18 to 44, 45 to 64, and 65 to 79 years, respectively. While in women, the estimates were 3.8, 11.5, and 11.9 cases per 1000 population in the same age categories, respectively.[15] Vaidya et al[16] showed that incident diabetes rates in the Kailuan cohort were 10.4, 17.5, and 17.9 cases per 1000 population in men aged 18 to 44, 45 to 64, and 65+ years, and 3.6, 13.1, and 19.5 cases per 1000 population in women of the same age groups. These findings indicated that both males and females showed higher percentage of diabetes with ages increasing, and males showed higher percentage of diabetes compared with females in the same age groups. Our findings were similar to them, by which the normal level of glucose was higher in aged cases compared with the young population (Table 5), and the percentage of participants having aberrant expression of glucose was higher in aged cases compared with the young population (Fig. 2). In our study, we found that participants in the 7th group (>80 years) showed reduced mean level of glucose from 2010 to 2016 overall. This may correlate with improved lifestyle such as moderate exercise, less fat, and sugar of each meal because most of these participants were cared for by their children in China. In a study on 11 Asian cohorts, the prevalence of diabetes increased with age and reached the peak at 70 to 89 years of age in Chinese and Japanese subjects but peaked at 60 to 69 years of age followed by a decline at the 70 years of age in Indian subjects. In addition, at 30 to 79 years of age, the 10-year age-specific prevalence of diabetes was higher in Indian than in Chinese and Japanese subjects. Interestingly, the Indian subjects showed a higher prevalence of impaired glucose regulation (IGR) in the younger age-groups (30–49 years) compared with that for Chinese and Japanese subjects. Impaired glucose tolerance was more prevalent than impaired fasting glycemia in all Asian populations studied for all age groups. The data indicated that Indians had the highest prevalence of diabetes among Asian countries. The age at which the peak prevalence of diabetes was reached was approximately 10 years younger in Indian compared with Chinese and Japanese subjects. This is partly in agreement with our findings, by which ages increasing accompanied with elevated levels of glucose.[17]

Yang et al[18] showed that the prevalence of diabetes was 9.7% (10.6% in men and 8.8% in women), and prevalence of prediabetes was 15.5% (16.1% in men and 14.9% in women) in a study on 46,239 nationally representative adults in 2007. Xu et al[19] estimated the prevalence of diabetes in China by fasting blood glucose, hemoglobin-A1c, and an oral glucose tolerance test to characterize glycemic control in 2010, where they found a prevalence of diabetes of 11.6% (12.1% in men and 11.0% in women) and prevalence of prediabetes of 50.1% (52.1% in men and 48.1% in women). These findings are similar to our study, where we find that the percentage of males having normal level of glucose was significantly lower than that in females. In other words, the percentage of males having abnormal level of glucoses was higher than females. Diet is able to affect glucose homoeostasis. In a follow-up study of Chinese adult population, Shi et al[20] discussed the association between meal-specific food patterns and incident hyperglycaemia, showing that traditional (wheat) breakfast was inversely associated with incident hyperglycaemia, whereas traditional (rice, vegetable and pork) lunch ;and dinner were positively associated with the risk of incident hyperglycaemia, even after adjustment for a number of covariates including glycaemic load, carbohydrate intake, and body mass index.

With socioeconomic growth, technological advancement, cultural changes, population growth, and accompanying lifestyle changes continue in China recently, the incidence of prediabetes and diabetes is rapidly increasing. Prediabetes is an intermediate category between normal glucose tolerance and overt diabetes. It is classified into 3 types: impaired fasting glucose (IFG), impaired glucose tolerance (IGT), and IFG combined with IGT. There are approximate 5% to 10% people with prediabetes that become diabetic annually.[21,22] Diabetes and prediabetes contribute to morbidity, mortality, and healthcare costs. Public health policies

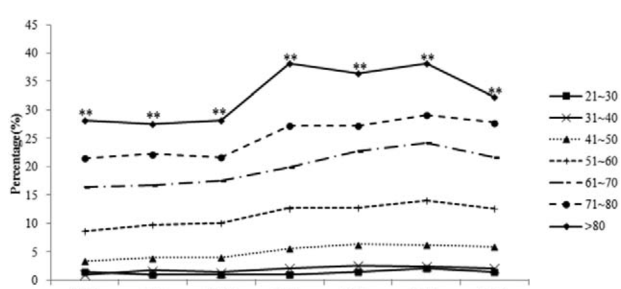

Figure 2. Trends of the percentage of cases with fasting blood glucose >6.2 mmol/L in different ages. The percentage of cases with fasting blood glucose >6.2 mmol/L in group 1 (18–20 years) and group 2 (21–30 years) was comparable every year. The percentage of cases with fasting blood glucose >6.2 mmol/L was gradually upregulated in groups 3 to 8 from 2010 to 2016 overall. Cases with older age showed significantly higher percentages than that in younger age every year ($^{**}P<.001$).

that target the early identification and prevention of prediabetes and diabetes might mitigate the individual health and societal burdens related to these diseases. Encouraging weight loss is considered to be an accepted intervention to lower blood glucose and ultimately down-regulate the incidence of diabetes.[23] Other factors such as smoking cessation, physical inactivity, and avoidance of dust and environmental exposures also seem to mitigate the incident risk of prediabetes and diabetes.

In fact, several trials have shown advantages in reducing the risk of developing diabetes among prediabetic individuals after lifestyle and drug-based interventions. The Diabetes Prevention Program (DPP) showed that lifestyle intervention can down-regulate the incidence by 58% after 2.8 years' intervention for prediabetes.[23] The Finnish Diabetes Prevention Study (DPS) reported that the cumulative incidence of diabetes was 11% in the intervention group and 23% in the control group after 4 years' lifestyle intervention for IGT.[24] Hu et al[25] assigned 434 with prediabetes to either the intervention group or the control group, and participants in the intervention group received synthetic intervention for 1 year. They found that the incidence of diabetes was 4.2% in the intervention group, while the incidence of diabetes was 19.7% in the control group. In addition, the intervention group experienced a great decrease in fasting glucose, body weight, waist circumference, total cholesterol, and HbA1c, at the end of 1 year compared with the control group, suggesting that synthetic intervention may be effective in reducing the risk of diabetes among individuals with prediabetes.

There are several limitations in the present study. First, impaired glucose tolerance, oral glucose tolerance test, and serum levels of hemoglobin-A1c were not examined though there were some cases with abnormal levels of glucose. Second, this study failed to discuss the causality relationship between blood glucose and related factors because of inherent limitations of the cross-sectional study. Third, the sampling in this study was conducted in a limited region of China, so the results of this study are not generalized to general Chinese or Asians. However, this was a large sample size study, by which participants were from the same area, supporting the accuracy and stability of the results.

In summary, participants in the current study showed higher levels of glucose with ages increasing, and males indicated higher expression of glucose than that in females. These results are considered as alarming for Chinese public health since steady rises in fasting blood glucose were seen.

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