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Original Article

Prevalence and Risk Factors of Type 2 Diabetes in the Adults in Haikou City, Hainan Island, China

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Abstract

Background: Type 2 diabetes mellitus (T2DM) occurs around the world with high prevalence and causes serious physical harm and economic burden to the afflicted. Haikou City is China's southernmost tropical island city, which has not been previously studied for its T2DM prevalence. The objective of the study in employing a cross-sectional survey is to discuss the epidemiologic status of T2DM in Haikou City and to analyze the possible determinants.

Methods: A total of 12,000 community residents over 18 years old from four districts in Haikou City were stratified-randomly sampled. A questionnaire survey and physical examination were conducted. Data entry and statistical analysis were performed using SPSS17.0 software.

Results: The prevalence of T2DM in Haikou City was 5.3% (5.15% for males and 5.46% for females). According to the multivariate analysis, the positive factors mainly associated with T2DM in the city included family history, Waist-to-Hip Ratio (WHR), triglycerides, low high-density lipoproteins (HDL), and blood pressure. For both men and women, family history was the highest independent risk factor associated with T2DM (OR= 47.128). The T2DM risk increased with increasing metabolic aggregate.

Conclusion: The prevalence of T2DM for the community population of Haikou City was low. The possible risk factors included age, occupation, BMI, waist circumference, WHR, overweight, systemic obesity, central obesity, systolic blood pressure, diastolic blood pressure, total cholesterol, triglycerides, low-density lipoproteins, family history, and HDL.

Keywords: Diabetes type 2, Prevalence, Risk factors, Epidemiology, Haikou

Introduction

Diabetes is a worldwide epidemic. Diabetes and obesity are now seen as a global epidemic (1). According to the statistics published by WHO in 2011, the number of people with diabetes around the world has reached 366 million, most of which are type 2 diabetes mellitus (T2DM). The countries with the fastest increase in incidence are developing countries, with dramatic differences exhibited from poor to rich financial statuses. In recent decades, rapid industrialization and urbanization in China has led to major changes in the patterns of complex diseases (e.g., T2DM) (2). The prevalence of diabetes in China is rapidly rising, and the country is set to become the second largest country for diabetes incidences after India. Diabetes is a lifelong disease with a wide range of complications, which bring the heavy burden of disease, disability, death, serious prognosis. One person dies of the disease every seven seconds, and 4.6 million people die of the disease each year. The majority of patients with diabetes have incapacity to control blood sugar, which leads to serious complications, such as heart disease, stroke, kidney, nerve and foot damage, blindness, and poor quality of life. Some patients would rather die than live. Therefore, we should actively study diabetes.

Many diabetes epidemiology studies have been conducted locally and abroad, most of which involve residents of urban communities, farmers, migrant workers, occupation groups, and high-risk groups. However, very few studies have been conducted on tropical island residents.

Haikou City is the capital of Hainan Island in China, which has a distinct economic development trend, social culture, geography, and climate. However, the T2DM prevalence among the residents, epidemic rule, and risk factors are still unknown.

Therefore, we carried out an epidemiological survey to analyze and conduct a preliminary estimate of the T2DM prevalence among the residents in the tropical island, analyze the epidemic rule and risk factors, and provide a scientific basis to propose appropriate prevention and intervention measures for the island population.

Materials and Methods

Sampling methods and sample size

Using stratified random sampling to study and analyze the current T2DM situation in Haikou City, the survey was conducted from September 2010 to September 2011. The objects were urban residents from four districts of the city. Three communities were randomly selected from each district, totaling 12 communities in all. One thousand subjects were sampled from each community, totaling 12,000 subjects.

Inclusion and exclusion criteria for selection

Inclusion criteria

Over 18 years old, a permanent resident in the sampled community, willing to sign the informed consent, answered the questionnaire and underwent the physical examination, recently not planning to move out of the community or be away for a long time (1 year and above).

Exclusion criteria

Unable to sign the informed consent, not a permanent resident of the sampled community, refused to provide true information, unable to answer the questionnaire, planning to move out of the community or be away for a long time (1 year and above).

Diagnostic criteria of T2DM

The diagnostic criteria for diabetes according to the WHO and the American Diabetes Association (ADA): arbitrary time plasma glucose ≥ 11.1 mmol/L; or fasting plasma glucose ≥ 7.0 mmol/L; or OGTT(oral glucose tolerance test) 2 hours glucose ≥ 11.1 mmol/L, and a repeated OGTT is desired for confirmation.

Implementation

Questionnaire survey

The questionnaire was designed by all members of the study group, and the investigators, comprising the researchers, community physicians, and students recruited from Hainan Medical College, were uniformly trained. Information obtained through the questionnaire included name, sex, date of birth, nationality, occupation, education degree, average annual household income, average annual personal income, marital status, reproductive history, disease history, smoking history, drinking history, diet, drinking water, exercise, and other lifestyle types and behaviors.

Physical examination and phlebotomy

The indicators determined through the physical examination included height, weight, and body mass index (BMI), among others. Venous blood was extracted (5 ml) and stored at −20 °C.

Laboratory testing

The standard enzymatic oxidation of glucose was used. Fasting blood glucose was tested within 2 hours after venous blood extraction. The blood indicators were analyzed using an automatic biochemical analyzer.

Quality Control

Implementing a pre-survey in the non-sampled communities; using a unified questionnaire; uniformly training the investigators; retesting abnormal glucose; implementing a data review and double-track entry.

Ethics points

The questionnaire survey and physical examination were conducted after the subjects signed the informed consent.

Data entry and analysis

Data entry and statistical analysis were performed using SPSS17.0 software. The distribution of diabetes, baseline data, and prevalence were described. Subsequently, the risk factors and causal association between diabetes and factors were analyzed by multiple logistical regression models.

Results

Demographic characteristics

The population characteristics of the different blood glucose levels are shown in Table 1. The subjects were divided into three groups according to blood glucose level, namely, normal fasting glucose (NFG) group, impaired fasting glucose (IFG) group, and T2DM group. The ages (mean ± standard error) were (48.32 ±0.52), (53.25 ± 0.73), and (56.81 ± 0.47) years old, respectively.

Table 1: The demographic characteristics and baseline data

Variables		NFG	IFG	T2DM	Total	*P*
		n=10524	n=840	n=636	n=12000	
Age		48.32(0.52)	53.25(0.73)	56.81(0.47)	49.12(0.26)	< 0.001
Sex	Male	51.05(0.45)	51.35(1.25)	49.56(2.05)	50.99 (0.36)	
	Female	48.95(0.38)	48.65(1.08)	50.44(2.10)	49.01 (0.23)	> 0.05
Ethnic	Han ethnic	99.30(0.08)	97.8(0.13)	99.5(0.15)	99.21(0.05)	
	Non-Han ethnic	0.70(0.11)	2.2(0.15)	0.5(0.13)	0.79(0.09)	> 0.05
Education	Lower than junior high school	53.36(0.28)	50.25(0.55)	57.35(0.36)	53.35(0.21)	
	Junior high school and above	46.64(0.20)	50.75(0.39)	42.65(0.41)	46.65(0.14)	> 0.05
Occupation	Mental	34.81(0.42)	37.32(0.64)	32.16(0.17)	34.78(0.14)	
	Non-mental	65.19(0.53)	63.82(0.41)	67.84(0.24)	65.22(0.20)	< 0.001
Marriage	Unmarried	12.36(0.35)	10.22(0.33)	8.82(0.43)	12.02(0.29)	
	Married	87.64(0.30)	89.78(0.45)	91.18(0.27)	87.98(0.21)	> 0.05
Average annual income (Yuan)	Household	10322(129.26)	9984(137.83)	11293(105.32)	10349.80(97.52)	> 0.05
	Personal	2321(42.36)	2724(15.42)	2563(28.31)	2362.04(13.46)	> 0.05
Smoking	No	57.32(0.71)	68.34(1.12)	71.91(0.98)	58.86 (0.68)	< 0.001
	Yes	42.68(0.45)	31.66(1.04)	28.09(0.73)	41.14 (0.35)	< 0.001
Drinking	No	72.74(0.38)	76.92(0.57)	80.08(0.24)	73.42(0.19)	< 0.001
	Yes	27.26(0.42)	23.08(0.61)	19.92(0.38)	26.58(0.27)	< 0.001
Regular exercise	No	90.34(0.37)	91.17(0.44)	92.26(0.51)	90.50(0.21)	< 0.001
	Yes	9.66(0.19)	8.83(0.47)	7.74(0.48)	9.50 (0.15)	< 0.001

Table 1: Cond…

Drinking tea	No	87.29(0.32)	90.24(0.24)	91.08(0.35)	87.70(0.18)	<0.001
	Yes	12.71(0. 24)	9.76(0.18)	8.92(0.27)	12.30(0.14)	<0.001
BMI (kg/m2)		23.53(0.05)	24.23(0.09)	24.85(0.11)	23.65(0.03)	<0.001
Waistline (cm)		76.85(0.12)	82.05(0.30)	83.27(0.33)	77.55(0.10)	<0.001
Waist to hip ratio		0.83(0.0003)	0.87(0.0015)	0.89(0.0023)	0.84(0.0002)	<0.001
Proportion of overweight		23.15(0.45)	34.83(1.55)	35.12(1.39)	24.60(0.39)	<0.001
Proportion of systemic obesity		7.93(0.57)	16.29(1.21)	19.43(1.53)	9.12(0.38)	<0.001
Proportion of central obesity		11.28(0.44)	43.47(1.63)	57.52(1.37)	15.98(0.32)	<0.001
Fasting plasma glucose (mg/dl)		93.41(0.08)	120.19(0.14)	173.54(1.03)	99.53(0.05)	<0.001
Systolic blood pressure (mmHg)		125.71(0.18)	133.25(0.74)	136.71(0.59)	126.82 (0.11)	<0.001
Diastolic blood pressure (mmHg)		77.65(0.15)	85.38(0.38)	84.72(0.44)	78.57(0.12)	<0.001
Total cholesterol (mg/ dl)		186.34(1.32)	197.81(1.51)	200.28(1.27)	187.88(0.93)	<0.001
High-density lipoprotein (mg/dl)		52.24(0.82)	51.07(1.36)	50.34(1.13)	52.06(0.72)	<0.01
Low-density lipoprotein (mg/dl)		105.49(2.81)	115.72(4.29)	116.03(3.42)	106.76(1.75)	<0.001
Triglycerides (mg /dl)		137.23(2.69)	170.53(3.21)	189.17(4.03)	142.31(1.89)	<0.001

Note: Data in the table is mean (standard error) or percentage (standard error), overweight (24≤BMI<28), systemic obesity (BMI≥28), central obesity (waistline: male≥85cm, female>80cm).

No significant differences in sex, ethnicity, education level, marital status, and income were observed among the three groups ($P > 0.05$). However, the other characteristics were significantly different among three groups ($P < 0.001$). These characteristics were age, occupation, BMI, waist circumference, WHR, the proportion of overweight, systemic obesity rates, the proportion of central obesity, fasting plasma glucose, systolic blood pressure, diastolic blood pressure, total cholesterol, high-density lipoproteins (HDL), low-density lipoproteins (LDL), triglycerides, smoking, alcohol consumption, regular exercise, and drinking tea, among others.

Compared with the NFG group, the BMI, WHR, systolic blood pressure, diastolic blood pressure, total cholesterol, triglycerides, and LDL values were higher in the IFG and T2DM groups. However, the HDL levels were lower in the latter groups. The proportion of overweight in the three groups(NFG group, IFG group,T2DM group) was 23.15%, 34.83%, and 35.12%, respectively, whereas the proportion of systemic obesity was 7.93%, 16.29%, and 19.43%, respectively. The prevalence of central obesity was 11.28%, 43.47%, and 57.52%, respectively. Therefore, the prevalence of overweight, systemic obesity, and central obesity significantly increased with blood glucose level.

Prevalence according to sex and age

Table 2 shows the variation in T2DM prevalence with gender and age. The prevalence in males belonging to the IFG and T2DM groups was 7.04% and 5.15%, respectively, whereas in females, the prevalence was 7.00% and 5.46%, respectively. No statistically significant difference was observed in the prevalence between males and females ($P > 0.05$).

Prevalence in the different age brackets(y<30, 30≤y<40, 40≤y<50, 50≤y<60, 60≤y<70, 70≤y) under the IFG group was 1.57%, 4.32%, 7.51%, 9.41%, 10.8%, and 10.07%, whereas in the T2DM group, prevalence was 1.52%, 3.61%, 5.23%, 8.07%, 7.14%, and 7.07%, respectively. Prevalence in both the IFG and T2DM groups showed a significantly increasing trend with age ($P < 0.0001$).

Table 2：IFG and T2DM prevalence of demographic characteristics (%)

Variables	N (12000)	IFG			T2DM		
		n_1(840)	P_1(%)	*P*	n_2(636)	P_2(%)	*P*
Sex							
Male	6119	431	7.04	＞0.05	315	5.15	＞0.05
Female	5881	409	7.00		321	5.46	
Age							
y＜30	1071	17	1.57	＜0.0001	16	1.52	＜0.0001
30≤y＜40	3385	146	4.32		122	3.61	
40≤y＜50	3123	235	7.51		163	5.23	
50≤y＜60	2064	194	9.41		167	8.07	
60≤y＜70	1406	152	10.81		100	7.14	
70≤y	951	96	10.07		67	7.07	

Multivariate analysis of T2DM risk factors

The multivariate logistic regression analysis of the T2DM risk factors is detailed in Table 3. The positive correlation factors for T2DM were family history of diabetes (OR=47.128; 95% CI=3.945–108.332), waist-to-hip ratio (OR=16.453; 95% CI=4.129–28.184), triglycerides (OR=1.527; 95% CI=0.428–2.314), low HDL level (OR=3.813; 95% CI=1.541–8.127), high blood pressure (OR=2.412; 95% CI=1.818–5.756).

The negative correlation factors for T2DM were lack of exercise (OR=0.813; 95% CI=0.414–5.138) and smoking (OR=0.703; 95% CI=0.291–1.036). The other factors that did not have any clear relationship with T2DM were central obesity (OR=0.903; 95% CI=0.325–4.223), total cholesterol (OR=1.094; 95% CI=0.587–3.426), and fruit intake frequency (OR= 0.932; 95% CI=0.349–1.108).

Table 3： Multivariate logistic regression analysis of T2DM risk factors

	β	SE	OR	95%CI
Family history	1.561	0.227	47.128	3.945-108.332
Waist to hip ratio	0.372	0.174	16.453	4.129-28.184
Central obesity	0.419	0.273	0.903	0.325-4.223
Total cholesterol	0.454	0.185	1.094	0.587-3.426
Triglyceride	0.004	0.012	1.527	0.428-2.314
Low HDL-C	-0.135	0.015	3.813	1.541-8.127
High blood pressure	0.257	0.007	2.412	1.818-5.756
Lack of exercise	0.311	0.129	0.813	0.414-5.138
Smoking	-0.413	0.191	0.703	0.291-1.036
Frequency of intake fruit	-0.077	0.017	0.932	0.349-1.108

Relationship between metabolic abnormalities aggregation and T2DM

The analysis of single indicators for the diagnosis of metabolic syndrome with T2DM showed that the effects of central obesity, high triglycerides, LDL, and total cholesterol were significant ($P < 0.001$; Table 4). The OR values were 2.827 (2.306–3.454), 2.413 (2.051–2.796), 5.971 (4.029–8.475), and 3.108 (3.608–2.457), respectively.

T2DM risk increased with the aggregate rising of abnormal metabolic indexes. When at least four abnormal metabolic factors aggregated at the same time, T2DM risk was the highest of all combinations (OR=13.285; 95% CI=5.812–22.459).

Table 4: Analysis of the relationship between combination factors and diabetes

	OR	**95%CI**	***P***
NO.	**1**	**-**	**-**
1	2.827	2.306-3.454	<0.001
2	2.413	2.051-2.796	<0.001
3	5.971	4.029-8.475	<0.001
4	3.108	3.608-2.457	<0.001
1+2	3.724	4.513-3.129	<0.001
1+3	8.937	4.521-13.028	<0.001
1+4	4.115	3.358-6.023	<0.001
2+3	7.247	5.021-12.243	<0.001
2+4	4.028	3.219-5.226	<0.001
3+4	9.736	4.249-15.738	<0.001
1+2+3	10.217	5.721-16.324	<0.001
1+2+4	5.049	4.531-7.828	<0.001
1+3+4	10.278	5.912-19.361	<0.001
2+3+4	11.392	5.147-18.728	<0.001
1+2+3+4	13.285	5.812-22.459	<0.001

Note: 1: central obesity, 2: high triglycerides, 3: low HDL, 4: Total cholesterol

Discussion

The epidemic state of T2DM varied widely among different regions, from less than 0.1% to 40%. The region with the highest prevalence rate is the Pacific island of Nauru and USA Pima Indians. Chicago scholars reported diabetes prevalence in subjects with sleep disorders to be as high as 30.1%, whereas that for normal sleepers were at a still high rate of 18.6% (3).

On January 9, 2012, the Chinese Health Education Center published a report entitled, “Chronic disease monitoring and diabetes thematic survey.” According to the report, the diabetes prevalence for Chinese residents aged 18 and over was 19.6% and 9.7%, respectively. The prevalence in men (10.2%) was higher than in women (9.0%), as well as in cities (12.3%) than in rural areas (8.4%). The number of adult diabetes patients totaled 9.700 million. Furthermore, more than one hundred million pre-diabetes cases were identified.

Diabetes prevalence is showing a rapidly increasing trend, whether in a developed or developing country. However, the present study showed that T2DM prevalence in Haikou City was 5.3% (5.15% in males, 5.46% in females), which is lower than the domestic and international prevalence rates.

A low prevalence rate was observed in this survey, which may be related to the natural conditions in Haikou City. Hainan Island is an international tourist island, which constitutes the Hainan Province, with Haikou City as the capital. Thus, the natural conditions and climate are unique in Haikou City. Haikou City is located on the tropical island of Hainan and experiences an oceanic tropical monsoon climate. The city also has other unique features, such as its tourism-dependent economy, geography, social and conditions. The economic development in the city has lagged behind the other Chinese cities. Thus, the relatively intense pressures characteristic of big city life are lesser the work pace and rhythm of life slower, and people’s lifestyles more leisurely and comfortable.

Of course, the low prevalence of T2DM observed in this study may also be related to the study design itself. Bias may have been produced from several steps in the study, such as survey design, sampling methods, sample size, quality control, implementation, and data analysis.

Data analysis showed significant differences among several factors between the NFG group and IFG or T2DM group. These factors included age, occupation, BMI, waistline, WHR, overweight, systemic obesity, central obesity, systolic blood pressure, diastolic blood pressure, total cholesterol, triglycerides, and LDL. Therefore, these factors were possible risk factors for T2DM. Overweight and obesity are the important risk factors, of which, obesity is considered a T2DM risk factor for adults. Weight gain is also an important risk factor (4–7). Obesity can induce resistance to insulin-stimulated glucose ingestion, which results in low insulin and high triglyceride concentrations, and promotes the occurrence of T2DM (8). A large number of epidemiological investigations also confirmed that overweight and obesity were associated with T2DM (9). With increasing age, T2DM prevalence showed a significant upward trend, indicating that age is also a possible risk factor. Multivariate analysis showed that the positive factors included family history, WHR, triglycerides, HDL, and hypertension. Multivariate logistic regression analysis showed that a family history of T2DM was a high-intensity independent risk factor associated with T2DM (OR=47.128). The T2DM prevalence in the first-degree relatives group was higher than that in the controlled group (26.6% versus 9.2%), thereby further strengthening the conclusion that family history is a risk factor (10). Central obesity, high triglyceride levels, insufficient HDL levels, and total cholesterol were related to the occurrence of T2DM. Furthermore, with an increasing number of metabolic aggregate, the possibility of T2DM risk also increased. The prospective study of Mykkanen on a population in Finland also confirmed this trend (11).

The majority of scholars believe that the phenomenal aggregation of a number of metabolic abnormalities exhibiting the physiological mechanisms for diabetes is associated with insulin resistance (IR), which is also an important risk factor. Based on the current data alone, we cannot determine whether the aggregation of the metabolic abnormalities leading to T2DM is a risk factor or just a sign of the severity level of the IR. However, evidence has shown that IR alone does not adequately explain the multi-factor aggregation.

The prospective study confirmed that metabolic abnormalities predicted the occurrence of T2DM, even independently of insulin levels (12). Therefore, further study about comprehensive intervention in the metabolic abnormalities is very necessary.

Based on further analysis of the aggregation combinations, even in the same aggregation number, the pathogenic role of the different combinations varied. The OR values indicated the varying roles, suggesting the possibility of different physiological mechanisms for T2DM. Factor analysis showed inherently different mechanisms affecting the aggregation among the indicators of interrelated metabolic syndromes (13, 14). Further investigation of the nature of these combinations is needed to identify the dose-response relationship and obtain further scientific data for the prevention of T2DM.

The multiple sources, etiology, and pathogenesis of T2DM as a complex disease have not been fully elucidated. Generally, environmental factors (especially lifestyle, exercise, and other factors) and genetic factors (especially the joint effect of a number of subtle genetic variations) are believed to be the causes (15).

The current study design obtained good representation and a large sample size, as well as T2DM demographic baseline data, prevalence, possible risk factors, and other present data on Haikou City. However, the current study also has limitations in the survey and analysis methods.

First, given that this study was a baseline survey, the study design was cross-sectional, and the possible exposure variables and outcome variables were collected at the same time; thus, the chronological order between exposure and outcome was not ignored, and causality was not obtained, thereby reducing the causal inference strength. The causal relationship was subject to certain restrictions, as well. Therefore, case-control and cohort studies, as well as population field and community trials should be carried out.

Second, a number of variables were obtained only through survey. Therefore, information bias was significant. In the data analysis phase, we were unable to assess and adjust the information bias; thus, the results deviated from the true exposure.

Third, in the data analysis phase, although the application of multivariate analysis techniques to control the confounding bias of demographic variables was performed, the confounding bias was not controlled because of unexpected external factors. Therefore, although the interpretation and application of the results were adequate, full consideration should be given to the potential bias and limitations of this study.

The T2DM prevalence among the community residents in Haikou City is lower compared with domestic and international rates. The possible risk factors for the population included age, occupation, BMI, waist circumference, WHR, overweight, systemic obesity, central obesity, systolic blood

pressure, diastolic blood pressure, total cholesterol, triglycerides, LDL, family history, and low HDL.
We urgently need to screen diabetes in high-risk populations, improve the awareness of the entire community on the risk factors and hazards of T2DM, and strengthen tertiary prevention to delay the onset age of T2DM, as well as reduce T2DM incidence and complications. Of course, we also should carry out various interventions, such as health education, health promotion, lifestyle management, weight control, and the promotion of a reasonable diet. For example, we should actively encourage the increased intake of cereal, fruits, vegetables, and tea, as well as the reduced intake of sugary beverages (16–20). Regular participation in physical activities is also helpful for patients to help control blood sugar (21). A multi-angle lifestyle management regime can help control the disease and reduce complications (22). Furthermore, establishing early warning mechanisms and models will help achieve the tertiary prevention and early detection of diabetes (23–24).

Conclusion

The prevalence of T2DM for the community population of Haikou City was low. The possible risk factors included age, occupation, BMI, waist circumference, WHR, overweight, systemic obesity, central obesity, systolic blood pressure, diastolic blood pressure, total cholesterol, triglycerides, low-density lipoproteins, family history, and HDL.

Ethical considerations

Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc) have been completely observed by the authors.

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