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Research Article

A Case-Control Study on the Effects of Youcha On Type 2 Diabetes Mellitus In Gongcheng County, China

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Abstract

Objective of the study is to explore the protective factors and risk factors of Youcha on type 2 diabetes mellitus in Gongcheng County. A 1: 2 matched case-control study conducted. Type 2 diabetes patients over the age of 35 were selected as the case group. A homogeneous population was used as the control group that are local residents, same age as case group ± 3 years, same sex, and no related chronic disease. A questionnaire survey was conducted with socio-demographic, family history, and drinking youcha habit, followed by physical examination and biochemical blood tests. Using the logistic regression model, the single factor and multivariate analysis were performed. The risk factors found were the family history of type 2 diabetes (OR = 12.28, 95%CI: 2.76-54.64); hypertension (OR = 7.32, 95%CI: 2.73-19.66); cardiovascular and cerebrovascular diseases (OR = 5.83. 95%CI: 2.61-13.00); and drinking youcha with fried food 54.9% vs. 35.2% (OR = 2.29, 95%CI: 1.35-3.87). The protective factors were daily drinking of 2 bowls of youcha 30.8% vs. 44.5% (OR = 0.40, 95%CI: 0.20-0.81); and daily-drinking 3 bowls 15.4% vs. 20.9% (OR = 0.39, 95%CI: 0.17-0.93) were all statistically significant. The analysis showed that drinking of 2-3 bowls of youcha is a protective factor for type 2 diabetes but drinking youcha with fried foods is a risk factor. Youcha when consumed in correct quantity can help reduce the incidence of type 2 diabetes.

Keywords: *Camellia oleifera*; Gongcheng County; Hypertension; Obesity; Peanut oil; Type 2 diabetes; Youcha

Abbreviations: IDF: International Diabetes Federation; Hba1c: Glycated Hemoglobin; WHO: World Health Organization; BMI: Body Mass Index; CDC: Center for Disease Control and Prevention; MET: Metabolic Equivalent; PAL: Physical Activity Level; EGCG: Epigallocatechin Gallate; EGC: Epigallocatechin Gallate

Introduction

An extensive national survey has documented that approximately 11.6% of Chinese adults 18 years and older have diabetes [1]. To control type 2 diabetes mellitus a variety of oral hypoglycemic drugs are used alone or in combination [2]. In uncontrolled diabetes, injectable form like insulin is used. However, there are many side effects associated with these medications. Besides, it has been shown that half of the outpatients in the metropolitan medical centers in China treated with oral hypoglycemic agents had inadequate glycemic control.[13] Due to their high cost and side effects associated with these synthetic drugs, there is a need for exploring the alternative natural anti-diabetic medicaments. Some plants can control diabetes due to their antioxidant and hypoglycemic effect [3,4]. Two such common to this research are *Camellia oleifera* and *Arachis hypogaea*.

Arachis hypogaea commonly known as peanut is a legume. It contains seeds that are a rich source of protein (25%to 28% and edible oil (43% to 55%). The peanut oil is a commonly used as edible oil all over the world, and China is the primary producer of it [5,6]. It has a high content of oleic acid, that help in reducing blood glucose and low-density lipoprotein [7]. *Camellia oleifera* or oil-tea is a shrub native to the south-central and southern China [8,9]. It is widely distributed in the provinces of the south China such as Guangxi [10]. The oil from the plant is taken out from the seeds, and it is primarily used as edible oil and in preparing many dishes [11-13]. It has been used since generations for the medicinal purposes [14,15]. Seeds of *Camellia oleifera* contain bioactive substances like flavonoids, polyphenols, polysaccharides, proteins, saponins, and unsaturated fatty acids and possess many bioactivities [16].

Gongcheng Yao autonomous county rated for China's longevity of the township, the secret of longevity may have a great relationship with Youcha. People in Guilin have the habit of drinking oil-tea. The most famous one is the Gongcheng oil-tea beverage commonly known as youcha, which is listed in the Provincial nonmaterial cultural heritage lists. It is a regular diet loved by the ethnic population. It is prepared by boiling tea leaves, ginger, garlic, peanut oil and oil-tea [17,18]. It is synonymous with having breakfast cereals in western countries. In addition to the above ingredients, puffed rice, cereal balls, and peanuts are added to the soup.

Gongcheng Yao Autonomous County is located in the northeastern part of Guangxi Zhuang Autonomous Region southwestern part of Guilin, China, spread over a total area of 2149 km^2. The entire population of the County is 0.29 million, out of which 0.24 million are agricultural population [19]. The prevalence of diabetes is much lower than the national average in Gongcheng Yao Autonomous County [20]. According to the China Health and Nutritional Survey, prevalence of type 2 Diabetes among adults in Guangxi is 7.5%. This lower prevalence of diabetes could be attributed to the Youcha drinking habit of the residents as suggested by previous studies. In this case-control study of type 2 diabetes was conducted to investigate the basic information, related health indicators, lifestyle and youcha drinking habits of type 2 diabetes patients and their controls. Furthermore, the study explores the protective factors and risk factors of diabetes mellitus in relation to youcha, and it's drinking habits.

Methods

Study Design and Survey Object

In this study, the participants were recruited from Gongcheng County hospitals and the Medical Insurance Center from 2014 to 2015. Type 2 diabetes patients are approved for new rural cooperative medical insurance, which is a government insurance and type 2 diabetes has been included in China's medical insurance reimbursement scope. New rural cooperative diabetes approval and the resident's health record of diabetes roster were used as a reference to collect the type 2 diabetes patients over the age of 35. Cases and controls were recruited in the ratio 1: 2 respectively. Inclusion criteria for case group include ≥ 35 years old patients with type 2 diabetes mellitus. The type 2 diabetes was confirmed according to the World Health Organization (WHO) diagnostic criteria for diabetes in public hospitals [21], which includes: (1) diabetic symptoms & plasma glucose levels at any time ≥ 11.1mmol/L or (2) Fasting plasma glucose levels ≥ 7.0 mmol/L. Patients suffering from type 1 diabetes mellitus, the special type of diabetes mellitus, malignant tumors and severe mental illness were not included among case group. Inclusion criteria for the control group were the local residence of Gongcheng, living more than one year, same age as case group $\pm$3 years, same sex, homogeneous population, and no related chronic diseases. A total of 326 patients were surveyed from July 2014 to October 2015, and 53 patients were excluded from the study. Among 273 patients, 91 were included in the case group and 182 in the control group.

Determination of Sample Size

The 1: 2 matched case-control study design was calculated as follows:

$$\eta = \frac{\left[Z_\alpha\sqrt{(1+1/r)\bar{p}(1-\bar{p})} + Z_\beta\sqrt{p_1(1-p_1)/r + p_0(1-p_0)}\right]^2}{(p_1-p_0)^2}$$

Among them: $p_1 = (OR \times p_0) / (1 - p_0 + OR \times p_0)$

$$\bar{p} = (p_1 + rp_0) / (1 + r)$$

n for the number of cases required for the study, matching the ratio of 1: 2. r = 2, and then control number of groups 2n can be obtained. $\alpha = 0.05$ (bilateral), $\beta = 0.1$, $Z\alpha = 1.96$ and $Z\beta = 1.28$.

Since obesity and overweight are risk factors for type 2 diabetes [22], it is essential to calculate the Body Mass Index (BMI) of the participants, (Table 1.1) shows BMI-related cutoff points for type 2 diabetes mellitus 1: 2 frequency-matched case-control sample size estimation.

Cut-off point	Estimated OR value (r)	Estimated sample size (n)	Estimated sample size of the control group (nXr)
BMI ≥ 24 kg/m^2	2.28	98	196
BMI ≥ 25 kg/m^2	2.46	82	164
BMI: Body Mass Index			

Table 1.1: BMI-related cutoff points for type 2 diabetes mellitus 1: 2 frequency-matched case-control sample size estimation.

Survey Methods

Questionnaire Survey

Gongcheng Yao Autonomous County's local Center for Disease Control and Prevention (CDC) staff assisted and followed the list of respondents via telephonic inquiries and made an appointment with the interested participants and conducted an investigation. A unified design approach for the questionnaire was constructed for both cases and control groups. The interview was carried out face-to-face by the local CDC staff on a one-on-one basis. The survey included information about socio-demographic characteristics, family details (that involve tracing family history of diseases till three generations), lifestyle habits (like dietary intake, smoking, drinking, physical activity, etc.), and Youcha drink (consumption, and frequency).

Household Sampling

In this study, we collected the sample and recorded the production and processing method of *Camellia oleifera* and how the locals commonly prepare the Youcha. The raw materials used to prepare the drink and the weight of *Camellia oleifera* used in the drink were recorded.

Medical Examination

Medical examination included measuring weight and height of participants for calculating BMI, measuring waist circumference and recording blood pressure. The following instruments were used for the examination:

Metal column height meter was used to measure the height with an accuracy of 0.1 cm. For weight, electronic weight scale was used with an accuracy of 0.1 kg. Waist circumference was measured by measuring tape with an accuracy of 0.1 cm, at the level of top curve of the hips and belly button. Blood pressure was measured by the standard mercury sphygmomanometer, and systolic and diastolic blood pressure was recorded according to the Korotkoff sounds. The blood pressure was recorded three times with an interval of 2 minutes between each recording. The average of the three measurements was used as high blood pressure.

Laboratory Testing

The blood samples were collected and centrifuged at 1500 g/min for 15 minutes. Fasting blood glucose and blood lipids (triglyceride, total cholesterol, and high-density lipoprotein) were determined by an automatic biochemical analyzer.

Blood glucose: measured by glucose oxidase method, the project for a single blood glucose measurement, but every ten samples to do a double sample determination. The principle of the experiment:

$$\text{Glucose} + O^2 + H_2O \xrightarrow{\text{Glucose oxidase}} \text{Gluconic acid} + H_2O_2$$

$$2H_2O_2 + \text{4-aminoantipyrine} + \text{p-hydroxybenzoic acid} \xrightarrow{\text{Peroxidase}} \text{Quinone imine} + 4\,H_2O$$

Serum cholesterol: Cholesterol Oxidase Amino Phenanthroline Method (CHOD-PAP) was used.

Serum triglycerides: phosphoglycerate oxidase 4-chlorate determination was used.

Serum high-density lipoprotein cholesterol: the direct method of determination was used.

All the laboratory tests were carried out in Guangxi Zhuang Autonomous Region CDC outpatient laboratory. To maintain the consistency, the laboratory test personnel, equipment and the batch of reagents for testing used were same.

Evaluation Criteria

Overweight, Obesity and Central Obesity

BMI in the range of 18.5- 23.9 kg/m^2 is considered as normal, below 18.5 kg/m^2 as underweight, a range of 24.0-27.9 kg/m^2 is considered overweight and BMI ≥ 28.0 kg/m^2 as obese, according to the Ministry of Health of the People's Republic of China [23,24]. In China, waist circumference >90 cm for males and >85 cm for females were recommended as the cut-off points for central obesity [25]. An increase in waist circumference is associated various health risks like diabetes, hypertension, and dyslipidemia [26,27].

Hypertension

According to the Chinese guidelines for prevention and control of Hypertension, a person is diagnosed as hypertensive if the systolic/diastolic blood pressure is ≥ 140/90 mmHg, and/or use of antihypertensive medication for the treatment of hypertension in the most recent two weeks [28,29].

Dyslipidemia

In the 2007 edition of the Chinese Guidelines on Prevention and Treatment of Dyslipidemia in Adults, defined dyslipidemia as any one of the following four conditions: hypercholesterolemia (total cholesterol ≥ 6.22 mmol/L); hypertriglyceridemia (triglycerides ≥ 2.26 mmol/L); low levels of high-density lipoprotein cholesterol < 1.04 mmol/L); high levels of low-density lipoprotein cholesterol ≥ 4.14 mmol/L) [30].

Smoking and Drinking

According to WHO, smoking is defined as continuous and cumulative smoking for six months or more in a lifetime [31] and drinking alcoholic beverages means drinking any alcohol (white wine, beer, wine, rice wine) in the past 12 months, for at least 12 times [32].

Physical Activity

Metabolic Equivalent (MET) is used for estimating energy expenditure during physical activity [33]. MET is the ratio of energy consumption per unit of body weight to basal metabolic energy expenditure per unit time, expressed in kcal or kJ [34]. It is a standard descriptor of physical activity levels across most modalities and all populations [35]. According to the Institute of Medicine, Physical Activity Level (PAL) is considered sufficient at when PAL ≥ 1.7, and insufficient when PAL ＜1.7. The formula used for calculating PAL is [36]

For Men:

$$\Delta PAL = [(A\ METs - 1) \times 1.34 \times (B\ min)/1440min)$$

where (1.34 = 1.15/0.9/0.95)

For Women:

$$\Delta PAL = [(A\ METs - 1) \times 1.42 \times (B\ min)/1440min)$$

where (1.42 = 1.15/0.9/0.91)

PAL = 1.0+ΔPAL

A is the physical activity intensity of activity.

B is the time to conduct the activity.

Quality Control

Questionnaire Design

The questionnaire was designed by the Guangxi Zhuang Autonomous Region CDC and presented to the Chinese CDC for review by relevant experts and discussed and revised after the pre-investigation.

Training of Investigators

All the surveyors participating in the on-site questionnaire survey were trained. The Guangxi Zhuang Autonomous Region and the Gongcheng County CDC staff carried out training and investigations. The investigation team members in the inquiry were not free to change if the replacement shall happen it was subjected to the consent of the investigation team head.

Grouping and Execution of Field Survey

The investigators were responsible for the on-site questionnaire survey, the completion of the questionnaire review and signed the completed questionnaires. Canton West CDC staff was responsible for the final review and signature confirmation. The household sampling of the food was carried by the Guangxi Zhuang Autonomous Region CDC unified distribution, and by the home investigation team, to ensure the authenticity of the survey data.

Physical Examination

Quality control medical team led by the Guangxi Zhuang Autonomous Region CDC, Gongcheng County CDC, and the Guangxi Autonomous Region CDC staffs were responsible for on-site supervision, and audit. Gongcheng County CDC staff was responsible for the resident's physical examination. Physical examination demanded the medical personnel in strict accordance with the requirements, values, clear and neat filling of the data. For measuring height, staff asked the participant to take off their shoes and hats to measure, accurate to 0.1 cm. For measurement of body weight, participants were asked to take off mobile phones and other heavy objects from their pockets, before the measuring the weight, accurate to 0.1 kg. And for waist measurement, participants were measured in an erect body position, relaxed abdomen, arms drooping naturally, feet close together to the lower edge of the midline line and the iliac crest line connecting the midpoint of the horizontal position of the measurement point. The measuring tape was affixed to the measured skin and survey subjects were advised to breath steady, measuring accuracy to 0.1 cm.

Laboratory Quality Control

Blood collection equipment by the Guangxi CDC has unified procurement allotted that involved in the physical examination of the participants. The staff collected 6ml fasting venous blood from the participants, on-site separation of serum and packaging was performed. Fasting blood glucose is tested for a unified supply at the Gongcheng County CDC, and reagents from the Guangxi Zhuang Autonomous Region CDC. Blood lipid testing unified sent to the Guangxi Zhuang Autonomous Region CDC Health Laboratory Division, using the same batch of reagents and the same instrument for testing.

Data Processing and Statistical Analysis

Questionnaires and laboratory testing data were double entered and validated with EpiData software (EpiData 3.0 for Windows; The EpiData Association Odense, Denmark). The data were then transferred into SPSS software (version 19.0; SPSS Inc., Chicago, IL, USA). Count data profiles were described using a test, for a 1: 2 matched case-control study. Single factor and multivariate analysis were performed by using the logistic regression model (CLRM). The COX regression model COXREG command was used to fit the data, and the minimum likelihood ratio regression method was used. The significance levels of entry and exclusion models were 0.10 and 0.05, respectively.

Results

(Table 2.1) summarizes the socio-demographic characteristics of the case and control groups. There are a total of 91 participants in the case group and 182 participants in the control group with a ratio of 1:2. Male to female ratio was 1:0.86 in both study populations. There was no statistical significance in the distribution of gender, age, ethnicity, marital status, educational level and occupational status between the two groups (P> 0.05). Case group and control group had better balance and comparability (P> 0.05). The only significant variable was per-capita annual income and cases with income <10,000 Yuan were more likely to be diabetic than those with higher income (53.8% vs. 46.2%; OR = 5.25, 95% CI: 2.72-10.13).

	Case group	Control group	*OR*[a]	*P*	*AOR*[b]	*P*
Variable	N(%)	N(%)	（*95%CI*）		(*95%CI*)	
Total participants	91	182				
Gender						
Male	49(53.8)	98(53.8)				
Female	42(46.2)	84(46.2)		1		
Age (years)						
≤54	24(26.4)	56(30.8)				
55-64	30(33.0)	63(34.6)				
≥ 65	37(40.7)	63(34.6)		0.59		
Ethnicity						
Non-Yao	24(26.4)	46(25.3)				
Yao	67(73.6)	136(74.7)		0.86		

Marital Status						
Unmarried/divorced/Widowed	16(17.6)	22(12.1)				
Married	75(82.4)	160(87.9)		0.22		
Educational level						
Junior high school and below	71(78.0	134(73.6)				
Senior high school and above	20(22.0)	48(26.4)		0.43		
Occupation						
Non - farming	15(16.5)	36(19.8)				
Farming	76(83.5)	146(80.2)		0.51		
Per-capita annual income						
<10,000 Yuan	49(53.8)	153(84.1)	1			
≥ 10,000 Yuan	42(46.2)	29(15.9)	5.25(2.72-10.13)	<0.01		
a: single factor analysis b: multiple-factor analysis						

Table 2.1: Socio-demographic characteristics of participants.

(Table 2.2), represents the place of birth and residence of three generations. The proportion of study population born in Gongcheng was 93.4% for case group and 98.4% for the control group, with no significant difference. The percentage of three generations who were born in Gongcheng was higher in control group 93.4% vs. 81.3%. Three generations include participant, participant's parents, and participant's grandparents. In Gongcheng residents the risk of type 2 diabetes in the three generations was 80% lower than non-Gongcheng residents.

	Case group	Control group	*OR*[a]	*P*	*AOR*[b]	P
Variable	N(%)	N(%)	(*95%CI*)		(*95%CI*)	
Born in Gongcheng						
No	6(6.6)	3(1.6)	1			
Yes	85(93.4)	179(98.4)	0.25(0.06-1.00)	0.05		
Birth place Gongcheng within three generations						
No	17(18.7)	12(6.6)	1		1	
Yes	74(81.3)	170(93.4)	0.26(0.10-0.63)	<0.01	0.20(0.07-0.62)	<0.01
a: single factor analysis b: multiple-factor analysis						

Table 2.2: Place of birth and residence of three generations.

(Table 2.3) represents the family history of diseases. The proportions of case group with the family history of type 2 diabetes mellitus were 14.3%, and the control group was 1.6%. Univariate logistic regression analysis shows that the family history of diabetes (OR = 12.28, 95% CI: 2.76-54.64) is a significant factor. Hypertension is another significant factor with 20.9% case group and 3.3% control group (OR = 7.32, 95% CI: 2.73-19.66). Cardiovascular and cerebrovascular diseases have the highest proportion of case group with 26.4% and control group were 4.9% (OR = 5.83. 95% CI: 2.61-13.00). There was no statistically significant difference in family history of coronary heart disease, stroke and malignant tumors between the case and the control groups.

	Case group	Control group	*OR*[a]	*P*	*AOR*[b]	*P*
Variable	N(%)	N(%)	(*95%CI*)		(*95%CI*)	
Type 2 Diabetes*						
No	78(85.7)	179(98.4)	1		1	
Yes	13(14.3)	3(1.6)	12.28(2.76-54.64)	<0.01	18.72(3.20-109.34)	<0.01
Hypertension						
No	72(79.1)	176(96.7)	1			
Yes	19(20.9)	6(3.3)	7.32(2.73-19.66)	<0.01		
Coronary heart disease						
No	77(97.4)	180(98.7)	1			
Yes	4(2.6)	2(1.3)	6.61(0.72-60.86)	0.1		
Stroke						
No	88(96.7)	181(99.5)	1			
Yes	3(3.3)	1(0.5)	6.00(0.62-57.68)	0.12		
Cancer						
No	86(94.5)	180(98.9)	1			
Yes	5(5.5)	2(1.1)	5.00(0.97-25.77)	0.05		
Cardiovascular and cerebrovascular diseases						
No	67(73.6)	173(95.1)	1			
Yes	24(26.4)	9(4.9)	5.83（2.61-13.00)	<0.01		
a: single factor analysis b: multiple-factor analysis						

Table 2.3: represents the participants' family history of diseases.

(Table 2.4) represents the lifestyle habits of the participants. The significant factors are physical activity and eat fruit every day. The proportions of case group and control group with sufficient physical activity were 25.3% vs. 41.2% respectively (OR = 0.45, 95% CI: 0.25-0.81). The proportions of the case group who eat fruit every day were 18.7%, and the control group was 30.8% (OR = 0.51, 95% CI: 0.27-0.95).

	Case group	Control group	*OR*[a]	*P*	*AOR*[b]	*P*
Variable	N(%)	N(%)	(*95%CI*)		(*95%CI*)	
Physical activity						
insufficient	68(74.7)	107(58.8)	1			

Sufficient	23(25.3)	75(41.2)	0.45(0.25-0.81)	<0.01		
Smoking						
No	64(70.3)	122(67.0)	1			
Yes	27(29.7)	60(33.0)	0. 50(0.41-1.54)	0.8		
Drinking alcohol						
No	68(74.1)	120(65.9)	1			
Yes	23(25.3)	62(34.1)	0.54(0.28-1.07)	0.08		
Eat alliaceous vegetables every day						
No	67(73.6)	127(69.9)	1			
Yes	24(26.4)	55(30.2)	0.84(0.49-1.44)	0.53		
Eat vegetables every day						
No	8(8.8)	17(9.3)	1			
Yes	73(91.2)	165(90.7)	1.07(0.45-2.56)	0.88		
Eat fruits every day						
No	74(81.3)	126(69.2)	1			
Yes	17(18.7)	56(30.8)	0.51(0.27-0.95)	<0.05		
a: single factor analysis b: multiple-factor analysis						

Table 2.4: Lifestyle habits of the participants.

(Table 2.5), summarizes physical and biochemical indexes of the participants. High BMI was significantly more frequent among the cases than among the controls, as was the waist circumference. Underweight (3.3% vs. 19.2%; OR = 0.22, 95% CI:0.06-0.74); overweight (31.9% vs. 12.1%; OR = 4.24, 95% CI:1.97-9.12); obesity (14.3% vs. 3.3%; OR = 6.11, 95% CI:2.03-18.33); BMI ≥ 24 kg/m^2 (36.3% vs. 9.9%; OR = 5.50, 95% CI: 2.68-11.28); and waist circumference male ≥ 90 cm; female ≥ 85 cm (46.1% vs. 14.5%; OR = 3.84, 95%CI: 2.13-6.94). Cases with diabetes were statistically significantly more likely than controls to have hypertension (63.7 vs. 36.3%; OR = 2.89, 95% CI: 1.71-4.89); and hypertriglyceridemia (27.5% vs. 13.2%; OR = 2.61, 95% CI: 1.35-5.06).

	Case group	Control group	*OR*^{a}	*P*	*AOR*^{b}	*P*
Variable	N(%)	N(%)	(*95%CI*)		(*95%CI*)	
BMI						
Normal, 18.5-23.9 kg/m^2	46(50.5)	119(65.4)	1			
Underweight, <18.5 kg/m^2	3(3.3)	35(19.2)	0.22(0.06-0.74)	<0.05		
Overweight, 24-27.9 kg/m^2	29(31.9)	22(12.1)	4.24(1.97-9.12)	<0.01		
Obesity, ≥ 28 kg/m^2	13(14.3)	6(3.3)	6.11(2.03-18.33)	<0.01		
BMI						
<24 kg/m^2	58(63.7)	164(90.1)	1		1	
≥ 24 kg/m^2	33(36.3)	18(9.9)	5.50(2.68-11.28)	<0.01	5.52(2.51-12.13)	<0.01
Waist circumference						

Male <90 cm; Female <85 cm	41(53.9)	130(85.5)	1			
Male ≥ 90 cm; Female ≥ 85 cm	35(46.1)	22(14.5)	3.84(2.13-6.94)	<0.01		
Hypertension						
No	33(36.3)	116(63.7)	1			
Yes	58(63.7)	66(36.3)	2.89(1.71-4.89)	<0.01		
Hypertriglyceridemia						
No	66(72.5)	158(86.8)	1			
Yes	25(27.5)	24(13.2)	2.61(1.35-5.06)	<0.01		
Hypercholesterolemia						
No	76(83.5)	162(89.0)	1			
Yes	15(16.5)	20(11.0)	1.59(0.77-3.27)	0.21		
Low High-density lipoprotein-C						
No	84(92.3)	172(94.5)	1			
Yes	7(7.7)	10(5.5)	1.52(0.51-4.49)	0.45		
High Low-density lipoprotein-C						
No	89(97.8)	178(97.8)	1			
Yes	2(2.2)	4(2.2)	1.00(0.18-5.46)	1		
Dyslipidemia						
No	58(63.7)	136(74.7)	1			
Yes	33(36.3)	46(25.3)	1.75(0.99-3.08)	0.05		
a: single factor analysis b: multiple-factor analysis						

Table 2.5: Physical and biochemical indexes of the participants.

(Table 2.6) shows that more than 95% of the survey population has the habit of drinking youcha. The proportions of case group and control group that have the statistically significant youcha drinking habit include daily drinking of 2 bowls of youcha 30.8% vs. 44.5% (OR = 0.40, 95% CI: 0.20-0.81); daily drinking 3 bowls 15.4% vs. 20.9% (OR = 0.39, 95% CI: 0.17-0.93); and drink youcha with fried food 54.9% vs. 35.2% (OR = 2.29, 95% CI: 1.35-3.87).

	Case group	Control group	*OR*[a]	*P*	*AOR*[b]	*P*
Variable	N(%)	N(%)	(95%CI)		(95%CI)	
The habit of drinking youcha						
No	4(4.4)	2(1.1)	1			
Yes	87(95.6)	180(98.9)	0.25(0.05-1.37)	0.11		
Drinking dose per day (bowl)						
0-1 bowl	24(26.4)	28(15.4)	1		1	
2 bowls	28(30.8)	81(44.5)	0.40(0.20-0.81)	<0.05	0.38(0.15-0.93)	<0.05

3 bowls	14(15.4)	38(20.9)	0.39(0.17-0.93)	<0.05	0.30(0.10-0.88)	<0.05
≥ 4 bowl	25(27.5)	35(19.2)	0.83(0.39-1.76)	0.62	1.02(0.41-2.58)	0.96
Consume puffed rice in youcha						
No	47(51.6)	89(48.9)	1			
Yes	44(48.4)	93(51.1)	0.89(0.54-1.49)	0.66		
Consume parched peanuts in youcha						
No	43(47.3)	81(44.5)	1			
Yes	48(52.7)	101(56.1)	0.90 (0.54-1.48)	0.67		
Drink Youcha with Fried food**						
No	41(45.1)	118(64.8)	1		1	
Yes	50(54.9)	64(35.2)	2.29(1.35-3.87)	<0.01	2.96(1.50-5.83)	<0.01
Consume porridge/rice/rice noodles in youcha						
No	41(45.1)	72(39.6)	1			
Yes	50(54.9)	110(60.4)	0.80(0.48-1.33)	0.38		
a: single factor analysis b: multiple-factor analysis						

Table 2.6: Youcha drinking habit of case group and control group.

Discussion

Studies have proven that diabetes mellitus results from the interaction between multiple factors like genetic, lifestyle and environmental risks factors [37]. The only significant socio-demographic characteristic of the participants is the per-capita annual income (the average exchange rate from July 2014 to October 2015 was U.S. 1 Dollar = 6.4 Chinese Yuan). Diabetes is noted more in low-income individuals. Previous studies demonstrated that prevalence of diabetes decreases steadily as income increases and there is a need to address the socioeconomic factors for the prevention and management of diabetes mellitus [38,39].

The Relationship Between Genetic Factors, Family History of Diseases and Type 2 Diabetes

Family history is an essential risk factor that shows the inherited genetic susceptibility to many diseases, common behaviors, and shared environment [40]. A three-generation pedigree is used for risk assessment or diagnostic consideration of various diseases [41,42]. This study found that the proportions of individuals whose birthplace is Gongcheng within three generations (grandparents, parents, and study individuals) have much lower prevalence of type 2 diabetes. This phenomenon may be related to the living environment, genetic factors, and eating habits. To confirm this, there is a need to carry out a post-migration epidemiological investigation. Previous studies have shown that type 2 diabetes has a very high genetic predisposition [43]. Mothers with type 2 diabetes have a greater impact on offspring than the fathers. For the prevention of type 2 diabetes and control, one should pay special attention to family aggregation, especially females with diabetes. There is a need to pay attention to control blood glucose, early diabetes screening, prevention, and awareness.

In our study, diabetes, hypertension, cardiovascular and cerebrovascular diseases were found to be significant when the family history of diseases was asked. Studies have shown that most early cardiovascular-related conditions like stroke, coronary heart disease, diabetes, and hypertension occur commonly in families with a positive family history of cardiovascular diseases [44].

Relationship Between Lifestyle Habits and Type 2 Diabetes

The results showed that individuals with insufficient physical activity have a higher risk of developing type 2 diabetes. Studies have shown that regular physical activity improves blood glucose control and can delay or prevent type 2 diabetes [45]. Physical activity increases glucose transfer through various pathways. It has independent effects on glucose transfer by raising both insulin-mediated and non-insulin mediated glucose transfer. Glycogen synthesis is also increased due to glycogen synthase activity resulting in the non-oxidative disposal of glucose. Insulin-induced glucose uptake in skeletal muscles is enhanced in individuals with sufficient physical activity [46]. To address the challenges facing diabetes, interventions need to recognize constraints on lifestyle changes and to identify effective strategies to switch lifestyle and behavioral patterns towards physical inactivity [47,48].

The proportions of individuals who consume fruits every day have 50% fewer chances of developing diabetes than those who do not consume fruits daily. Several studies after examining the dietary pattern and incidence of type 2 diabetes have concluded that vegetables and fruits are essential elements of diet that are associated with a decreased risk of type 2 diabetes [49,50]. The precise mechanism by which vegetables and fruits reduce the risks of diabetes is not known. A combination of phytochemicals and antioxidants like carotenoids and Vitamin C found in vegetables and fruits might promote health by withstanding free radicals that are associated with the initial phase of development of chronic diseases [51]. American Diabetes Association recommends that diabetics should consume high fiber-containing foods such as vegetables, fruits and whole grains [52]. However, consumption of vegetables and alliaceous vegetables are not found to be significant in our study. A similar finding demonstrated by a European study, which found that the fruit consumption was related to slightly stronger protective association towards the risk of development of type, 2 diabetes than vegetables [53]. This can be linked to higher vitamin C content of commonly consumed fruits like strawberry, citrus, kiwi, and berries [54]. There is a need to determine further the eating frequency and the type of fruits and vegetables that have more effect on type 2 diabetes. Our finding renders the beneficial effect of eating fruits daily.

Studies have shown that smoking increases the risk for type 2 diabetes [55] and moderate alcohol consumption reduces the risk of type 2 diabetes by 30% [56,57]. But in our study population, both smoking and alcohol consumption factors were insignificant.

Relationship Between Physical and Biochemical Indexes and Type 2 Diabetes

BMI is a crude estimate of general obesity. Waist circumference helps to determine central obesity, which is a strong predictor of diabetes [58]. In this study, we have used both the measures for assessing obesity. Univariate analysis showed overweight, obesity and central obesity, and multivariate analysis showed general obesity as statistically significant with type 2 diabetes. Obesity is the major risk factor for type 2 diabetes [59,60]. Moreover, people with diabetes have impaired glucose tolerance mostly because of obesity and the associated metabolic syndrome [61]. One interesting finding of our study is that underweights had statistically significant diabetes. Previous studies have shown the high prevalence of diabetes in the underweight population [62]. With increasing rates of obesity among the Chinese people, early onset of type 2 diabetes has become a severe public health issue, and there is a need for interventions at the governmental level to control the type 2 diabetes. There is a need to improve reasonable dietary intake and increase physical activity to curb the epidemic of obesity.

Diabetes is associated with a variety of complications like hypertension, dyslipidemia, and hypertriglyceridemia. About 64% of the cases and 36% of controls have hypertension in our study. Studies have shown that 75% of diabetics have concomitant hypertension [63,64]. The oleic acid in peanut oil and tea oil can inhibit and prevent hypertension and cardio-cerebrovascular diseases [65,66]. Studies have shown that activity of adrenoreceptor signaling pathway (both α- and β-adrenoceptors) that control the blood pressure can be regulated by oleic acid [67]. Further studies needed to explore the exact mechanism by which hypertension is controlled. Hyperlipidemia is a form of dyslipidemia, which is a group of metabolic disorders caused by hypertriglyceridemia and/ or hypercholesterolemia [68].

Hypertriglyceridemia is significantly twice as high in the case group than control group. According to the China Health and Nutritional Survey, prevalence of hyperlipidemia in Guangxi is 40.2%. Hypertriglyceridemia occurs in conjunction with low high-density lipoprotein and high low-density lipoprotein (bad cholesterol) and is associated with increased cardiovascular disease risk especially in diabetics [69,70]. The percentage of oleic acid in peanut oil ranges from approximately 39% to 81%, as the peanut oil composition is influenced by genetic, and environmental factors [71]. Studies conducted by Zhu, et al. demonstrated that *Camellia oleifera* could significantly improve lipid metabolism and lower hyperlipidemia in rats. The oil in *Camellia oleifera* contains 80% oleic acid, which is known to reduce low-density lipoprotein and total cholesterol in humans [72,73]. A study by Suzuki et al. suggested that heated tea extract have the higher hypolipidemic effect than non-heated tea extract. This possibly indicates that youcha, that is prepared by boiling is very effective in releasing active ingredient, the oleic acid that helps in reducing hyperlipidemia [74].

Relationship Between Youcha Consumption and Type 2 Diabetes

The anti-diabetic effect of youcha is related to the oleic acid and polyphenols. The oleic acid found in peanut oil increases the insulin secretion in the insulin-secreting cells called INS-1. Also, oleic acid enhances insulin secretion in the presence of inflammatory cytokine TNF-∝.[24] TNF-∝ plays a pathogenic role in glucose metabolism. Both in vivo in animals and humans and in vitro in animals have demonstrated a direct effect of TNF-∝ on insulin sensitivity in skeletal muscle. It inhibits the insulin-signaling cascade at the Akt substrate 160 and insulin receptor substrate (regulatory proteins) [75].

Additionally, the polyphenols in *Camellia oleifera* oil increases the insulin activity and augment metabolic and vascular actions of insulin, thereby controlling hyperglycemia [76]. A human clinical trial reported that supplementation with green tea extracts reduced HbA1c in borderline diabetics [77]. The insulinpotentiating activity of tea is majorly contributed by polyphenols, Epigallocatechin Gallate (EGCG) followed by Epigallocatechin Gallate (EGC) and other components like catechins [78]. EGC and EGCG are found in high quantities in *Camellia oleifera* [79]. EGCG exerts insulin-like effects at cellular levels like repression of glucose production and Phosphoenolpyruvate Carboxykinase (PEPCK) and Glucose-6-Phosphatase (G6Pase) gene expression [80].

Our study is first of its kind in determining the habitual characteristics of drinking youcha and its association with type 2 diabetes. More than 95% of residents have the habit of drinking youcha in our study. An analysis of the relationship between youcha consumption and daily consumption found that most locals consume 2-3 bowls. In the multivariate analysis, it is found that drinking 2-3 bowls (200ml-300ml) of youcha is a protective factor for type 2 diabetes, and drinking less than 2 bowls or more than 3 bowls were not found to be statistically significant. This shows a dose-dependent response relationship, which is similar to the previous studies conducted between concentration of green tea and blood glucose level [81].

There is a definite association between fried food consumption and type 2 diabetes [82]. In our study drinking youcha with fried food is significant and is a risk factor for type 2 diabetes. However, consuming puffed rice, parched peanuts, rice noodles or porridge rice in youcha are not found to be significant. This could be related to the high amount of oil used in cooking fried food and not in other mentioned foods preparations. Frying causes destruction of food nutrients as unsaturated fatty acids, antioxidant, and vitamins are lost due to oxidation [83,84]. The high intake of trans fat in cooking oil may produce abdominal obesity, which is an essential factor in developing type 2 diabetes [85]. Consuming youcha with fried food should be avoided, as the unsaturated fatty acids are lost leading to decrease beneficial effect of youcha.

While current standards for type 2 diabetes management suggest the need to maintain HbA1c under 7.0%, the need for non-medicated alternatives should be highly considered. The consumption of youcha (with the peanut oil and tea-oil) should be used as an alternative to synthetic drugs that can help in delaying the diabetes occurrence or prevent it. The low prevalence of diabetes in Gongcheng County possibly due to consumption of youcha should be a learning lesson for the rest of the world. Change in lifestyle habits like more physical activity, eating fruits daily, and consuming less or no fried foods should be encouraged for the general population. These interventions along with diabetes education should be implemented at the governmental level involving public health personnel and organizations. Past studies have shown that comprehensive lifestyle interventions effectively reduce the incidence of type 2 diabetes [86]. Blood lipid control and weight control are crucial to decreasing the prevalence of diabetes. Diabetic patients should also pay attention to the effective control of blood pressure and obesity to reduce the incidence of diabetes-related complications.

The present study has several strengths. It is the first study to identify and examine the protective and risk factors of youcha for the prevention of type 2 diabetes. A strict quality assurance and quality control program was implemented at every phase of the study to ensure data validity and reliability. The data from physical examination was gathered to a precision of 0.1 units. For biochemical indexes, the data was controlled, by using the same batch of reagents and the same instruments. One limitation of the study is that self-administered questionnaire of family history involving three generations can lead to bias. The surveyors specified for the family history of type 2 diabetes. Since, neither the medical records nor the blood samples of the three generation pedigree were available or considered in the study, it could be possible that the participants have included family members with the history of other forms of diabetes like type 1 diabetes. Since the prevalence of other forms of diabetes is low, there is a shallow level of potential misclassification of diabetes. Also, the study is limited to recall bias to assess food intake.

Conclusion

The obese residents of Gongcheng County, especially central obesity and those with the family history of diabetes have a higher risk of type 2 diabetes. Hypertension is an independent risk factor for type 2 diabetes. Diabetic patients should pay attention to the effective control of hypertension to reduce the incidence of diabetes-related complications. In addition, change in lifestyle habits like adopting more physical activities and intake of the healthy diet can help to control type 2 diabetes. Our analysis showed that drinking of 2-3 bowls of youcha is a protective factor for type 2 diabetes but drinking youcha with fried foods is a risk factor. An alternative to synthetic medications, youcha made from peanut oil and *Camellia oleifera* oil when consumed at correct quantity can help reduce the incidence of type 2 diabetes mellitus.

Contributorship Statement

Zhifeng Fang and Zhenzhu Tang were responsible for conception and design of this study.

Zhifeng Fang, Ting Zhu, Zhongyou Li, Yuzhu Chen, Xiaopeng L, Qin He, Xuan He, Huafeng Chen, Zhenzhu Tang performed the study.

Ting Zhu, Yousuf Mohammed Adnan, Yuhua Ruan Wensheng Fan involved in the data cleaning and statistical analysis.

Zhifeng Fang, Ting Zhu, Yousuf Mohammed Adnan, Zhenzhu Tang, Yuhua Ruan Wensheng Fan accomplished the drafted manuscript.

All the authors have reviewed and approved the final manuscript.

Competing Interests

None.

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Data sharing

Supplementary data is available by contacting Ting Zhu, ju20121225@163.com

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