Original Article

Association between oil tea intake and the risk of type 2 diabetes in adults: A cross-sectional study in Gongcheng, Guangxi, China

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Background and Objectives: The associations between oil tea and type 2 diabetes (T2D) have been little studied in the population. This study aimed to evaluate whether oil tea intake is related to the reduced risk of T2D in adults. **Methods and Study Design:** A rural-based cross-sectional study was conducted in Gongcheng Yao Autonomous County, Guangxi, southern China (2018–2019), with a total of 3178 population included in the final analysis. A multivariable logistic regression model was used to analyze the associations between the intake frequency, daily intake of oil tea and the risk of T2D. We further compared the association differences between the daily intake of oil tea and the risk of diabetes under different dietary patterns, which were generated from food frequency intake data using principal factor analysis. **Results:** The differences in the frequency and daily intake of oil tea in both groups (diabetes group and the non-diabetes group) were statistically significant ($p<0.05$). After adjusting for age, sex, smoking status, physical activity, body mass index (BMI), compared with non-oil tea drinkers, intake ≥3 times /d had an inverse association with T2D (OR=0.417; 95% CI: 0.205–0.848, $p<0.05$); while daily intake of more than 600 mL/d but less than 900 mL/d was significantly associated with reduced T2D risk (OR=0.492; 95% CI: 0.284–0.852, $p=0.011$). In the Chinese traditional dietary and the plant-based dietary model, compared with the non-oil tea drinkers, the fourth intake group had a lower risk of diabetes, with an OR (95%CI) value of 0.500 (0.291–0.854) and 0.505 (0.298–0.855), respectively, but no statistical significance (All $p>0.05$). **Conclusions:** Our study suggests that oil tea was associated with a reduced risk of T2D aged 30 years or older.

Key Words: oil tea, type 2 diabetes, fasting plasma glucose, daily intake, dietary pattern

INTRODUCTION

Oil tea is one of the most popular types of traditional tea beverages in Guangxi, whose main ingredients are green tea, ginger, and oil (Mainly peanut oil). According to China National Food Hygiene Standard Method Analysis and evaluation of the nutritional components of oil tea mainly include tea polyphenols, gingerol, total fat, moisture and dietary fiber, etc. It is heated by a unique local teapot and is made by repeatedly tapping with a tea hammer and adding hot water to it as the following detailed process: Soak the selected green tea leaves with a little boiling water for 5-10 minutes to reduce the smoke and bitterness smell. Then put a little peanut oil in the teapot to heat, add the ginger and stir-fry, then add the soak green tea leaves and beat them, add water to boil them

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until the flavor comes out, refined salt to taste, and then filter the oil tea into a bowl with a funnel. As a specialty drink of the Yao ethnic, Chinese medicine believes that oil tea is a compound preparation of traditional Chinese medicine, with the functions of invigorating the spleen and eliminating food, dispelling cold, avoiding obstacles, soothing the surface, and stopping diarrhea.[1] One research group had assessed the composition of oil tea, including tea polyphenols, gingerol, caffeine, etc.[2] Green tea and ginger have each been demonstrated to exert antidiabetic effects, including cohort studies,[3,4] animal experiments,[2,5-7] clinical randomized controlled trials.[8,9] However, there is little research on whether oil tea has anti-diabetic effects and its mechanism.

Diabetes mellitus describes a group of metabolic disorder character raised by increased blood glucose concentration. With the improvement of the economic level and changes in eating habits, the prevalence of diabetes has increased significantly. According to the latest epidemiological study data covering 31 provinces, the total number of adult diabetic patients in China is about 129.8 million, and the prevalence rate of diabetes is as high as 12.8%, ranking first in the world.[10] Diabetes had a dramatic increase in all countries, both in rural and urban areas. Type 2 diabetes, which was previously regarded as a disease of the elderly, is now becoming younger and even appears in a small number of teenagers. It is predicted that the number of people with diabetes in China will reach 151 million by 2040. The huge and rapidly increasing burden of type 2 diabetes (T2D) in the world has made primary prevention a public health imperative.

Therefore, implement effective T2D prevention strategies and early detection programs is essential to reduce the health burden caused by diabetes.[11] Nowadays, our prevention and treatment of T2D are not limited to insulin and other hypoglycemic medicine but from lifestyle and diet adjustments. As a convenient adjustment factor, the diet has also attracted the attention of the world and has been considered a remarkable factor in preventing T2D.[12] Several studies have reported and examined the associations between diabetes and foods, the presence of certain nutrients and trace elements, such as brown rice,[13] milk and dairy product,[14] and magnesium.[15] Previous studies have shown that low-fat dairy products may be associated with lowering the risk of type 2 diabetes in middle-aged and elderly women.[16,17] And One of the concern factors about the impact of food on diabetes is tea consumption. Drinking tea can reduce the risk of type 2 diabetes by affecting the body's intake and digestion of glucose, and protecting pancreatic β cells from free radical damage. Therefore, we further investigated whether oil tea with tea as the main ingredient has the effect of lowering blood glucose in the cross-sectional population. Simultaneously, meals that people eat actually contain many different foods and nutrient combinations rather than individual nutrients.[18] Consequently, dietary pattern analysis has become a way to examine the relationship between diet and a variety of chronic diseases. It takes into account the comprehensive effects of nutrients and can propose healthy nutritional intake recommendations, such as dietary patterns to prevent chronic diseases.

To our knowledge, no prior studies on oil tea intake and the risk of type 2 diabetes exist, and studies on oil tea and blood glucose were limited. Therefore, we investigated the association between oil tea intake and type 2 diabetes in the Gongcheng area, southern China. Then we also analyzed the dietary patterns of this population and incorporated the dietary patterns into the multivariate regression model to analyze the association between the intake of oil tea and the risk of T2D under different dietary patterns.

METHODS

Subjects

The study was based on the Gongcheng Yao Autonomous County ecological longevity cohort in Guangxi, China. A total of 4356 residents over 30 years old were recruited from two towns of Gongcheng from December 2018 to November 2019, they underwent physical examination, demographic baseline survey, and food-frequency questionnaire (FFQ). Then, we excluded the following objects: did not complete the physical examination, suffered from serious diseases, or type 1 diabetes, lost questionnaire information. A total of 3178 subjects were included in the final study (1199 men and 1979 women).

All participants' written informed consent was obtained before further examinations. And the study protocol was approved by the Ethics and Human Subject Committee of Guangxi Medical University and Guilin Medical University (No.20170703-1; No.20180702-3).

Data collection

The examinees' weights were measured with a calibrated electronic digital scale under the condition of wearing light clothes and no shoes, and the height is measured with a safe portable tachymeter. Waist circumference (WC) was measured with a soft ruler at 1cm above the belly button. The fasting venous blood of the examinee was collected by the nurse at the physical examination center of the local township health center. Then, the blood sample was used to determine serum total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), fasting plasma glucose (FPG), and glycosylated haemoglobin (HbA1C) based on an automatic clinical chemistry analyzer (Hitachi 7600-020, Kyoto, Japan) in the laboratory of the People's Hospital of Gongcheng Yao Autonomous County.

A baseline questionnaire was used to collect the demographic information of the subjects such as gender, age, education level, occupational, smoking, drinking (alcoholic beverage), disease history, physical activity. Oil tea intake was assessed by trained researchers using a validated, semi-quantitative oil tea designed to assess average oil tea intake in the past year (the past 12 months). We use the questionnaire to collect the oil tea intake of the population, including the age when they started drinking, the frequency and intake dose per time, and the various raw ingredients and dosages in the previous year. Moreover, we also used a FFQ refer to Liu et al[19] to record the main food intake of the subjects during the previous year, the types of food include rice, noodles and corn, total vegetables, total fruits, pulses, beans and peas, nuts, preserved and red meat, offal, white meat, fish, seafood,

aquatic products, eggs, milk, yogurt, alcoholic drinks, salt and edible oil, total 109 kinds of foods that frequently consumed by a middle-aged Chinese.

Assessment of oil tea intake

For the oil tea and diet, subjects were asked to recall and report their average consumption frequency and the estimated portion size of the previous year, using Chinese traditional weight units (1 Liang = 50 g) or natural units (oil tea bowl = 300 mL). Moreover, the frequency of oil tea intake was classified as follows: Non (never or occasionally), less than once a day (1-3 times/month, 1-2 times/week, 3-4 times/week, 5-6 times/week), once a day, 2 times/day, and ≥3 times/day. Then, the selected frequency category was converted to a daily intake and used for further analysis. The daily intake = amount/per time × intake frequency, Evaluation of intake of oil tea and raw ingredients(green tea, ginger, and oil, etc.) consumption of oil tea: The research subjects selected a natural oil tea bowl to describe the amount of oil tea substitution and purchased various raw ingredients needed for oil tea from the local market to simulate for the steps of oil tea, the amount of various raw ingredients is weighed in sequence with an electronic balance, which is accurate to 0.1 g.

Definition

The latest recommendations from the American Diabetes Association[20] for diabetes were used for the definitions of the following related variables: fasting plasma glucose (FPG) ≥126 mg/dL (7.0 mmol/L); Oral glucose tolerance test (OGTT) 2h blood glucose value ≥200 mg/dL or glycosylated hemoglobin (HbA1c) ≥48 mmol/mol (6.5%); or history of diabetes. Fasting plasma glucose and HbA1c data were combined for diagnosis. Physical activity was measured by labour situation according to the labour intensity grading standards recommended in the Physical Activity Guidelines (PAG):[21] light (mainly sitting, standing, or unable to work normally, etc.), moderate (mainly general physical activity, etc.), vigorous (mainly heavy physical labour, etc.). Marital status is divided into two groups: married or cohabiting, unmarried or divorced (widowed, divorced, separated). According to the years of education, the education level was divided into 2 groups: Incomplete primary or lower and complete primary or higher. Body mass index (BMI) was calculated by weight (kg)/height (m^2). Participants were classified as underweight (BMI <18.5 kg/m^2), normal weight (BMI 18.5-24.9 kg/m^2), overweight (BMI 25-29.9 kg/m^2) and obese (BMI ≥30 kg/m^2).[22] Oil tea intake frequency was divided into 5 groups according to Non, less than once a day, once a day, 2 times/d, and ≥3 times/d. Moreover, according to the local consumption habits of oil tea, the daily intake was divided into 5 groups according to Non, <300 mL/d, 300-600 mL/d, 600-900 mL/d, ≥900 mL/d.

Statistical analysis

We tested the normality of continuous variables by using the Kolmogorov-Smirnov test. Data of all continuous variables that do not obey normality were presented as median and IQR. The included study subjects were divided into the diabetes group and non-diabetes group. The chi-square test was used to assess the difference for categorical variables of the baseline data, while the Mann-Whitney U test was used to describe mean differences for continuous variables of the clinical characteristics and dietary factors of participants. Multivariable logistic regression models were adjusted for age, gender, smoking status, physical activity, and BMI, to estimate the OR and 95% CI for diabetes according to frequency, daily intake of oil tea and quartiles of each oil tea ingredient consumption. Dietary patterns were generated from food frequency intake data using principal factor analysis. We further explored the associations between dietary patterns and daily intake of oil tea using the binary logistic analysis. All statistical analyses were performed using the statistical package SPSS 25.0, and 2-tailed p values <0.05 were considered statistically significant.

RESULTS

Participant characteristics

A total of 3,178 people in the study took health examination, bio-chemical indicators testing and completed questionnaires, including 1,199 men (37.7%) and 1,979 women (62.3%), aged 30 to 95, with a mean age (44.0±13.3 years). The overall prevalence of type 2 diabetes in this population was 12.5%, with the male was 5.9% and the female was 6.6%. The characteristics according to participants with and without diabetes are shown in Table 1. Differences in age, gender, smoking status, education level, marital status, physical activity, BMI, frequency of oil tea intake, daily intake, and the consumption of the ingredients were statistically significant in diabetes and non-diabetes groups (p<0.05). (Table 1).

Table 2 shows a comparison of the clinical characteristics of participants with different diabetes status. The FPG and HbA1C of the diabetes group were higher than those of the non-diabetes group. The M (IQR) of the FPG of the two groups were 4.7 (4.3, 5.1) mmol/L and 5.9 (5.0, 7.6) mmol/L, respectively. The comparison of other blood biochemical indicators also shows the TC, LDL-C, TG, and HDL-C, uric acid (UA), Systolic blood pressure (SBP), Diastolic blood pressure (DBP), and WC levels in the diabetes group were higher than those in the non-diabetes group, and the differences were all statistically significant (p<0.05).

Association of oil tea intake with the risk of diabetes

Median (IQR) total green tea, ginger, and oil consumption (main ingredients of oil tea) in this population were 28.0 (18.9, 39.0) g, 34.8 (19.8, 48.0) g, 10.5 (6.0, 20.0) g, respectively. According to the IQR of the consumption, the subjects are divided into groups Q1-Q4. The OR (95% CI) for the risk of type 2 diabetes according to the oil tea intake and its' ingredients were shown in Figure 1. After adjusting for age, gender, smoking status, physical activity, and BMI, participants with oil tea intake ≥3 times a day had lower odds of diabetes risk (OR=0.417; 95% CI: 0.205–0.848, p<0.05) than those have no oil tea intake. Interestingly, compared with Non-drinkers, daily intake with more than 600mL but less than 900mL had a lower odds of diabetes risk (OR=0.492; 95% CI: 0.284–0.852, p=0.011), while no statistical significance was found for those who drink more than 900mL a day (OR=0.823; 95% CI: 0.477–1.419, p=0.483), either for

Table 1. Characteristics of 3178 study participants

Characteristics	Overall（N=3178）	Diabetes status (%)		*p*-value
		Non-diabetes	diabetes	
Gender, n (%)				<0.001
Male	1199 (37.7)	1012 (36.4)	187(47.0)	
Female	1979 (62.3)	1768 (63.6)	211(53.0)	
Age (y), n (%)				<0.001
35–44	365 (11.5)	357 (12.8)	8 (2.0)	
45–54	825 (26.0)	752 (27.1)	73 (18.3)	
55–64	830 (26.1)	715 (25.7)	115 (28.9)	
65~	1158 (36.4)	956 (34.4)	202 (50.8)	
Marital status, n (%)				0.002**
Unmarried or divorced	530 (16.7)	442 (15.9)	88 (22.1)	
Married or cohabiting	2648 (83.3)	2338 (84.1)	310 (77.9)	
Education level, n (%)				0.012*
Incomplete primary or lower	1333 (41.9)	1143 (41.1)	190 (47.7)	
Completed primary or higher	1845 (58.1)	1637 (58.9)	208 (52.3)	
Occupational, n (%)				0.568
Farmers	2940 (92.5)	2569 (92.4)	371 (93.2)	
Else	238 (7.5)	211 (7.6)	27 (6.8)	
Physical activity, n (%)				<0.001
Light	1320 (41.5)	1105 (39.7)	215 (54.0)	
Moderate	1786 (56.2)	1617 (58.2)	169 (42.5)	
Vigorous	72 (2.3)	58 (2.1)	14 (3.5)	
Smoking, n (%)				
No	2597 (81.7)	2290 (82.4)	307 (77.1)	0.011*
Yes	581 (18.3)	490 (17.6)	91 (22.9)	
Drinking, n (%)				
No	2147 (67.6)	1894 (68.1)	253 (63.6)	0.069
Yes	1031 (32.4)	886 (31.9)	145 (36.4)	
Oil tea frequency, n (%)				0.016*
Non	124 (3.9)	102 (3.7)	22 (5.5)	
Less than once a day	79 (2.5)	71 (2.6)	8 (2.0)	
Once a day	1225 (38.5)	1065 (38.3)	160 (40.2)	
2 times/d	1433 (45.1)	1255 (45.1)	178 (44.7)	
≥3 times/d	317 (10.0)	287 (10.3)	30 (7.6)	
Daily intake of oil tea, n (%)				0.031*
Non	124 (3.9)	102 (3.7)	22 (5.5)	
<300 mL/d	756 (23.8)	663 (23.8)	93 (23.4)	
300~600 mL/d	1166 (36.7)	1020 (36.7)	146 (36.7)	
600~900 mL/d	660 (20.8)	595 (21.4)	65 (16.3)	
≥900 mL/d	472 (14.8)	400 (14.4)	72 (18.1)	
BMI, n (%)				<0.001
Underweight (<18.5)	241 (7.6)	212 (7.6)	29 (7.3)	
Normal weight (18.5–24.9)	2173 (68.4)	1955 (70.3)	218 (54.8)	
Overweight (25–29.9)	651 (20.5)	522 (18.8)	129 (32.4)	
Obese (≥30)	113 (3.5)	91 (3.3)	22 (5.5)	
Green tea consumptions, g, M (P25, P75)	28.0 (18.9, 39.0)	35.0 (20.0, 48.0)	32.0 (18.0, 46.0)	<0.001
Ginger consumptions, g M (P25, P75)	34.8 (19.8, 48.0)	28.5 (19.0, 39.2)	26.0 (17.0, 38.5)	<0.001
Oil consumptions, g, M (P25, P75)	10.5 (6.0, 20.0)	10.5 (6.0, 20.0)	6.0 (10.0, 20.6)	<0.001

BMI: body mass index.
*p-value <0.05.

the other two intake groups. The same inverse association was observed with green tea consumption in the adjusted model; compared to the lowest quartile of consumption, those in group Q3 had a significant association to lower rate of T2D (OR=0.705; 95% CI: 0.522–0.951, p=0.022). We found a null association between ginger, oil consumption and T2D risk (OR comparing highest vs. lowest was 0.819 and 1.181, respectively, p for all>0.05).

Dietary patterns

The factor-loading matrixes for these dietary patterns were presented in Table 4. Three dietary patterns were obtained through factor analysis (Kaiser-Meyer-Olkin: KMO=0.778; p<0.05). The first, Chinese traditional dietary pattern (feature value: 2.635) was loaded by a high intake of whole grains, total vegetables, fresh fruits, beans and its products, white meat, fish, and seafood. The second is the western dietary pattern (feature value: 1.261), with the characteristic of high intakes of red meat, processed meat, offal, and alcoholic beverages. Third, a plant-based dietary pattern (feature value: 1.003) was characterized by a high intake of fruits, vegetables, beans, and so on. Overall, these three dietary patterns accounted for 23.9%, 11.5%, and 9.1%, respectively, of the 44.5% total variance. In western dietary pattern, the daily intake of oil tea may be associated with the risk of diabetes. As shown in Figure 2, compared with non-drinkers, the risk of diabetes in the higher intake group is higher, the OR

Table 2. The main phenotypic characteristics of the study participants

Variables	Diabetes status M (P25, P75)		z	*p*-value
	Non-diabetes(n=2780)	Diabetes(n=398)		
Age, (y)	60.0 (50.0, 67.0)	65.0 (56.0, 70.0)	-8.8	<0.001
BMI, kg/m^2	22.3 (20.2, 24.5)	23.6 (21.0, 26.2)	-6.1	<0.001
FPG (mmol/L)	4.7 (4.3, 5.1)	5.9 (5.0, 7.6)	-19.8	<0.001
HbA1C (%)	5.7 (5.4, 6.0)	6.8 (6.5, 7.5)	-30.5	<0.001
UA (mmol/L)	287 (237, 351)	327 (263, 396)	-7.6	<0.001
TC (mmol/L)	5.5 (4.8, 6.2)	5.6 (5.0, 6.3)	-2.9	<0.001
LDL-C (mmol/L)	3.4 (2.8, 4.0)	3.5 (2.9, 4.2)	-3.2	<0.001
TG (mmol/L)	1.0 (0.7, 1.6)	1.2 (0.8, 2.1)	-5.5	<0.001
HDL-C (mmol/L)	1.7 (1.5, 2.0)	1.6 (1.4, 1.9)	-3.1	<0.001
SBP (mmHg)	130 (118, 148)	139 (126, 156)	-6.7	<0.001
DBP (mmHg)	80.0 (73.0, 89.0)	84.0 (76.0, 94.0)	-4.9	<0.001
WC (cm)	77.8 (71.0, 84.0)	82.0 (75.0, 90.0)	-7.8	<0.001

BMI: body mass index; FPG: fasting plasma glucose; HbA1C: glycosylated haemoglobin; UA: uric acid TC: serum total cholesterol; LDL-C: low-density lipoprotein cholesterol; TG: triglycerides; HDL-C high-density lipoprotein cholesterol; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; WC: waist circumference.

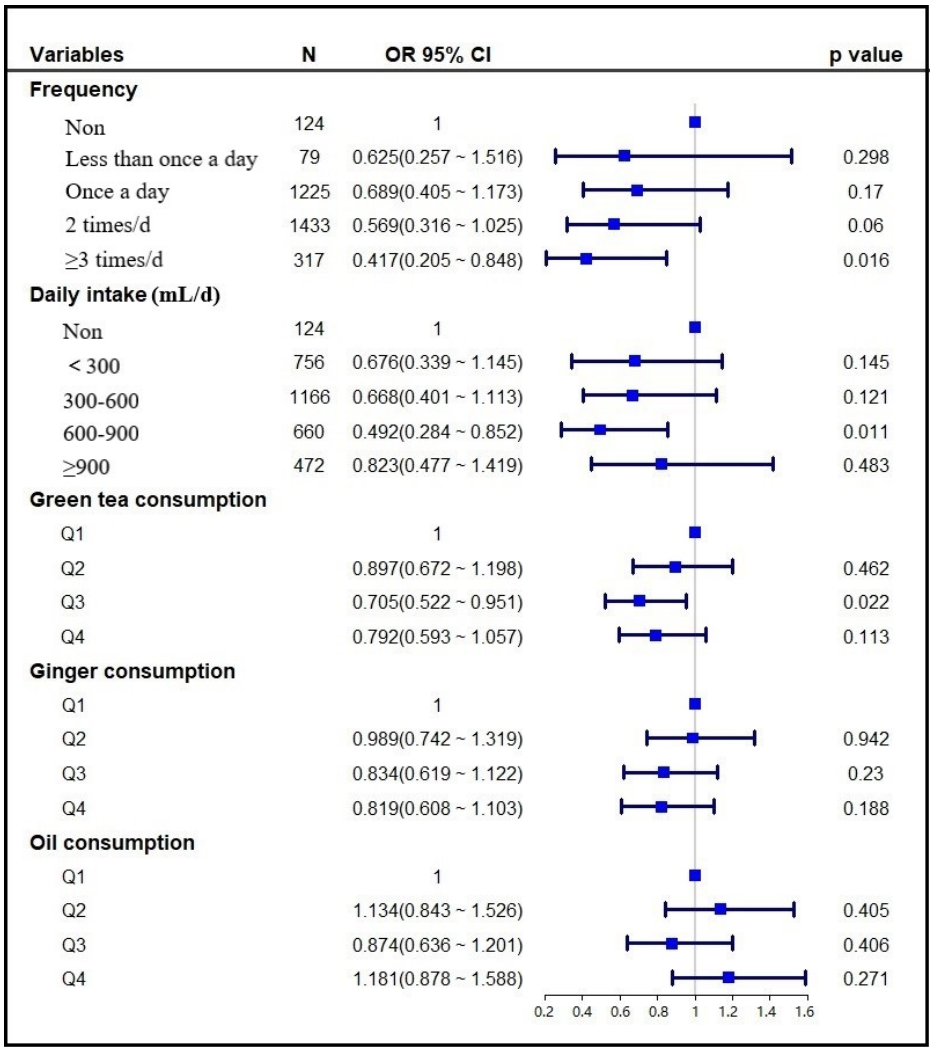

Figure 1. The associations between frequency, daily intake of oil tea and the risk of type 2 diabetes. The model was adjusted for gender, age, smoking, physical activity, education level, and BMI.

(95% CI) value is 1.037 (0.595–1.414), but no statistical difference. Under the Chinese traditional dietary pattern, compared with the non-drinkers group, the '600–900 mL/d' intake group had a lower risk of diabetes, with an OR (95% CI) value of 0.500 (0.291–0.854). This is consistent with the trend of the results analysed before the diet was not included.

DISCUSSION

In the current cross-sectional study of Gongcheng middle-aged and elderly population, with a relatively higher intake of oil tea drink compared to Chinese other rural area populations, we found that that oil tea intake contributes to the reduction of T2D risk. The intake frequency of oil tea (≥3 times/d) and daily intake (600-900 mL/d), and

Table 3. The demographic and characteristics of the study participants according to the frequency of oil tea intake

Variables[†]	Oil tea intake frequency					*p*-value[‡]
	Non (n=124)	Less than once a day (n=79)	Once a day (n=1225)	2 times/day (n=1433)	≥ 3 times/day (n=317)	
Number of participants (N=3178)	124 (3.9)	79 (2.5)	1225 (38.5)	1433 (45.1)	317 (10.0)	——
Gender, n (%)						0.241
Male	52 (41.9)	28 (35.4)	436 (35.6)	566 (39.5)	117 (36.9)	
Female	72 (58.1)	51 (64.6)	789 (64.4)	867 (60.5)	200 (63.1)	
Age (y), n (%)						<0.001
35–44	12 (9.7)	21 (26.6)	155 (12.7)	125 (8.7)	52 (16.4)	
45–54	38 (30.6)	24 (30.4)	341 (27.8)	315 (22.0)	107 (33.8)	
55–64	31 (25.0)	18 (22.8)	335 (27.3)	374 (26.1)	72 (22.7)	
65~	43 (34.7)	16 (20.3)	394 (32.2)	619 (43.2)	86 (27.1)	
Marital status, n (%)						0.007*
Unmarried or unmarried	32 (25.8)	18 (22.8)	187 (15.3)	250 (17.5)	43 (13.6)	
Married or cohabiting	92 (74.2)	61 (77.2)	1038 (84.7)	1183 (82.5)	274 (86.4)	
Education level, n (%)						<0.001
Incomplete primary or lower	62 (50.0)	23 (29.1)	446 (36.4)	667 (46.6)	135 (42.6)	
Complete primary or higher	62 (50.0)	56 (70.9)	779 (63.6)	766 (53.4)	182 (57.4)	
Occupational, n (%)						0.001
Farmers	105 (84.7)	71 (89.9)	1121 (91.5)	1342 (93.7)	301 (94.9)	
Else	19 (15.3)	8 (10.1)	104 (8.5)	91 (6.3)	16 (5.1)	
Physical activity, n (%)						<0.001
Light	82 (66.1)	45 (57.0)	530 (43.3)	548 (38.2)	115 (36.3)	
Moderate	42 (33.9)	33 (41.8)	657 (53.6)	858 (59.9)	196 (61.8)	
Vigorous	0 (0.0)	1 (1.2)	38 (3.1)	27 (1.9)	6 (1.9)	
Drinking [§], n (%)						0.326
No	104 (83.9)	65 (82.3)	1021 (83.4)	1151 (80.3)	256 (80.8)	
Yes	20 (16.1)	14 (17.7)	204 (16.6)	282 (19.7)	61 (19.2)	
Smoking, n (%)						0.005*
No	96 (77.4)	58 (73.4)	829 (67.7)	933 (65.1)	231 (72.9)	
Yes	28 (22.6)	21 (26.6)	396 (32.3)	500 (34.9)	86 (27.1)	
Body mass index, kg/m^2	22.8 (20.7, 25.2)	22.6 (20.5, 26.3)	22.7 (20.4, 24.9)	22.1 (20.2, 24.5)	22.4 (20.2, 24.6)	0.006*
FPG	4.7 (4.2, 5.2)	4.6 (4.4, 5.0)	4.7 (4.3, 5.1)	4.8 (4.4, 5.3)	4.6 (4.3, 5.0)	<0.001
HbA1C	5.8 (5.4, 6.1)	5.6 (5.3, 6.0)	5.7 (5.4, 6.1)	5.8 (5.5, 6.1)	5.7 (5.4, 6.0)	0.002*

BMI: body mass index; FPG: fasting plasma glucose; HbA1C: glycosylated haemoglobin; UA: uric acid; TC: serum total cholesterol; LDL-C: low-density lipoprotein cholesterol; TG: triglycerides; HDL-C high-density lipoprotein cholesterol; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; WC: waist circumference.

[†]All continuous variables were shown as n (%) or median (25th, 75th).

[‡]Chi-square test for categorical variables while the Mann-Whitney U test for continuous variables across the different groups.

[§]Drinking represents drinking alcoholic beverages.

*p-value<0.05.

Table 3. The demographic and characteristics of the study participants according to the frequency of oil tea intake (cont.)

Variables[†]	Oil tea intake frequency					*p*-value[‡]
	Non (n=124)	Less than once a day (n=79)	Once a day (n=1225)	2 times/day (n=1433)	≥ 3 times/day (n=317)	
TC	5.3 (4.8, 6.2)	5.2 (4.5, 6.0)	5.4 (4.8, 6.1)	5.5 (4.9, 6.3)	5.4 (4.7, 6.1)	0.004*
LDL-C	3.3 (2.7, 3.9)	3.1 (2.7, 3.9)	3.4 (2.8, 4.1)	3.4 (2.8, 4.1)	3.3 (2.6, 3.9)	0.023*
TG	1.2 (0.8, 1.8)	1.1 (0.7, 1.8)	1.1 (0.8, 1.7)	1.0 (0.7, 1.5)	1.1 (0.8, 1.6)	<0.001
HDL-C	1.6 (1.4, 1.9)	1.6 (1.4, 1.8)	1.6 (1.4, 2.0)	1.7 (1.5, 2.0)	1.7 (1.5, 2.0)	<0.001
UA	299 (248, 384)	292 (237, 347)	298 (242, 366)	288 (238, 354)	275 (233, 334)	<0.001
SBP	127 (116, 138)	122 (114, 134)	130 (118, 148)	134 (119, 152)	131 (117, 148)	<0.001
DBP	78.0 (71.0, 89.8)	79.0 (71.0, 86.0)	81.0 (74.0, 91.0)	81.0 (73.0, 90.0)	80.0 (73.0, 88.0)	0.027*
WC	79.8 (73.3, 86.9)	81.0 (72.0, 89.6)	80.0 (72.0, 86.0)	77.0 (71.0, 84.0)	78.0 (70.0, 84.0)	<0.001
Rice, noodles & corn, g/d	517 (309, 705)	475 (344, 831)	517 (343, 752)	519 (361, 750)	505 (340, 758)	0.921
Total vegetables, g/d	189 (118, 339)	201 (103, 384)	214 (108, 398)	209 (113, 372)	212 (125, 394)	0.794
Total fruits, g/d	124 (58.6, 298)	164 (59.2, 314)	146 (64.4, 332)	143 (64.5, 309)	155 (76.8, 333)	0.511
Pulses, beans & peas, g/d	39.5 (23.0, 80.1)	39.5 (23.0, 88.8)	42.7 (19.3, 85.5)	42.7 (16.9, 85.5)	49.0 (21.4, 95.3)	0.201
Nuts, g/d	3.9 (0.0, 17.5)	4.9 (0.3, 11.3)	4.9 (0.7, 14.1)	4.0 (0.4, 13.1)	5.8 (0.7, 18.6)	0.053
Preserved, read meat & offal, g/d	50.0 (23.5, 100.0)	34.3 (13.2, 81.6)	38.6 (15.5, 82.2)	37.5 (15.5, 80.6)	52.3 (19.3, 98.1)	0.041*
White meat, g/d	6.6 (1.6, 14.7)	6.6 (3.3, 9.9)	6.6 (1.6, 13.2)	6.6 (1.6, 13.2)	6.6 (1.6, 13.2)	0.199
Fish, seafood & aquatic products, g/d	6.6 (1.6, 19.7)	6.6 (1.6, 16.4)	6.6 (1.6, 16.4)	6.6 (1.6, 16.4)	6.6 (3.3, 19.7)	0.128
Eggs, milk & yogurt, g/d	43.2 (13.0, 71.9)	39.3 (21.3, 76.9)	36.2 (11.8, 76.3)	37.9 (12.5, 78.1)	41.3 (13.0, 80.5)	0.640
Alcoholic drinks, g/d	0.0 (0.0, 5.5)	0.0 (0.0, 9.9)	0.0 (0.0, 19.9)	0.0 (0.0, 13.5)	0.0 (0.0, 9.9)	1.000
Edible oil and salt, g/d	64.8 (35.9, 92.8)	65.0 (41.7, 91.6)	62.9 (39.9, 93.2)	57.8 (38.0, 85.7)	60.8 (43.3, 92.5)	0.048*

BMI: body mass index; FPG: fasting plasma glucose; HbA1C: glycosylated haemoglobin; UA: uric acid; TC: serum total cholesterol; LDL-C: low-density lipoprotein cholesterol; TG: triglycerides; HDL-C high-density lipoprotein cholesterol; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; WC: waist circumference.

[†]All continuous variables were shown as n (%) or median (25th, 75th).

[‡]Chi-square test for categorical variables while the Mann-Whitney U test for continuous variables across the different groups.

[§]Drinking represents drinking alcoholic beverages.

*p-value<0.05.

Table 4. Factor loadings of the three dietary patterns of 3178 study participants

Food groups (% variance)	Chinese Traditional dietary pattern (23.9%)	Western dietary pattern (11.5%)	Plant-based dietary pattern (9.1%)
Rice, noodles & corn	0.416	—	—
Total vegetables	0.543†	—	0.316
Total fruits	0.433	0.516†	0.200
Pulses, beans & peas	0.582†	0.365	0.260
Nuts	—	0.338	0.328
Preserved, read meat & offal	—	0.666†	—
White meat	0.687†	—	—
Fish, seafood & aquatic products	0.701†	—	—
Eggs, milk & yogurt	—	0.562†	—
Alcoholic drinks	—	0.693†	—
Oil & other dressings	—	—	0.881†

Food groups with factor load ≥0.20 & ≤-0.20 are displayed.
†Food groups with factor load ≥0.50.

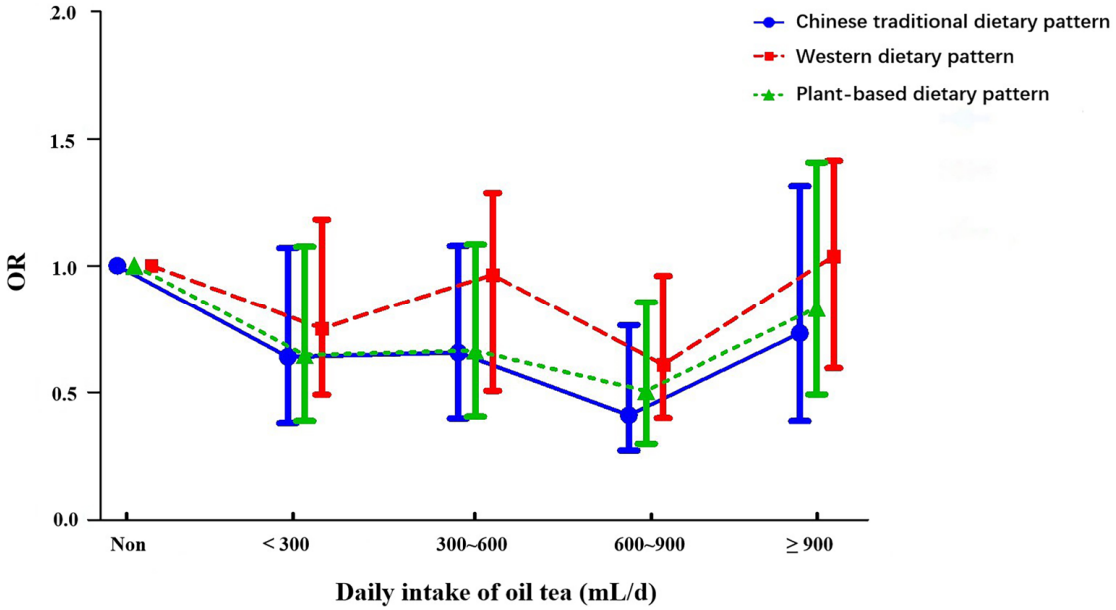

Figure 2. Daily intake of oil tea and prevalence of type 2 diabetes under different dietary patterns risk linkage. Chinese traditional dietary pattern: high intake of whole grains, total vegetables, fresh fruits, beans and its products, white meat, fish, and seafood. Western dietary: with the characteristic of high intakes of red meat, processed meat, offal, and alcoholic beverages. Plant-based dietary pattern: high intake of fruits, vegetables, beans, and so on.

green tea consumption (Q3 group) were related to reducing the risk of diabetes, but the intake and green tea consumption are neither the higher the better, not the lower the better. The current findings provide further insights for a better understanding of the link between the combined effects of oil tea intake and diet patterns and the prevalence of diabetes.

As a complex mixture of green tea, ginger, and oil, Lin et al. confirmed that oil tea improved serum glucose levels and glucose tolerance and modulated gut microbiota in db/db mice,[2] They also found that oil tea can improve the body's glucose homeostasis by down-regulating the genetic marker phosphoenolpyruvate carboxykinase 1 (PCK1), which is mainly involved in glycolysis/gluconeogenesis pathways. The two SNPs in PCK1 (rs707555 and rs2071023) were significantly related to T2D in Guangxi minorities.[23] The latest research on Guangxi oil tea shows that it has a certain effect of scavenging free radicals, preventing free radicals from damaging pancreatic islet cells and protecting their functions, reducing blood glucose, and improving antioxidant effects.[24] Zhang et al observed in experiments that the mechanism of action of oil tea extract in reducing blood glucose in type 2 diabetic mice may be related to its promotion of 3T3-L1 preadipocyte differentiation and then up-regulation of PPARγ gene expression and improvement of insulin resistance in T2D.[25] Previous research on oil tea has mainly stayed at the level of animal experiments and genes and has not been verified in the population. This cross-sectional study first discovered the anti-diabetic effect of oil tea in a population. However, the research data shows that the effect obtained with daily intake 600 mL~900 mL was better than that of more than 900mL. The reason may be that body has a tolerance to oil tea, which means that body's response to the components in oil tea was reduced. The daily intake should be controlled in dosage to ensure the best effect of oil tea.

This study had shown that green tea consumption in the third quartile can significantly reduce the risk of diabetes, but not in the highest quartile, and after adjusting for confounding variables, the same results still exist. As the most important ingredient of oil tea is green tea, we be-

lieve that the green tea ingredient plays the role in lowering blood glucose. In a cohort study of 0.5 million Chinese adults, compared with participants who never drank tea in the past year, drinking tea, especially green tea, has an inverse association with the risk of T2D.[26] Our findings also corroborated well with a study on the Chinese population in Fujian Province, which demonstrated the inverse associations between green tea consumption and IFG.[27] Moreover, studies in mice have indicated that green tea contributes preventive and therapeutic effects on hyperglycaemia of T2DM model,[28] down-regulate gluconeogenesis enzymes,[29] bind to the active site of α-amylase and α-glucosidase, acting as an inhibitor, and have an anti-diabetic effect.[30] The main anti-diabetic effect of green tea is its extract epigallocatechin gallate (EGCG), which can regulate the enzymes involved in glycogen synthesis, thereby enhancing insulin-mediated glucose metabolism.[31]

However, research on green tea and diabetes and blood glucose levels are heterogeneous. A previous study reported that green tea drinkers had an increased risk of T2D [HR=1.20 (95% CI=1.14-1.27)] compared with non-current drinkers,[32] one of the possible explanations is the pesticide residues on the tea leaves. The other meta-analysis showed green tea consumption did not decrease the levels of fasting plasma glucose either.[33] We assume that may be related to the different study populations and the number of people among studies.

Notably, the association between oil tea intake and the risk of T2D may be affected by dietary patterns. In a meta-analysis of 20 confirmed studies,[34] including 1,218,380 individuals from the United States, Europe, Australia, and Asia reported that eating large amounts of red and processed meat is positively associated with diabetes, and eating processed meat every day was associated with 19% higher diabetes risk with diabetes. Preserved meat contains a lot of nitrates and their by-products may resist insulin,[35] and impair glucose tolerance.[36] Meanwhile, the omega-3 polyunsaturated fatty acid contained in fish[37] and high dietary fibers intake[38,39] has been reported to have a protective role against diabetes. Furthermore, the null association in pattern 2 could be due to reverse causality. Participants with diabetes diagnosed previously may be advised to change their dietary behaviour and food choices and reduce edible oil intake. All in all, these possibilities cannot be excluded from our analyses.

Our study had strengths and limitations. This is the first large-scale study concerning the topic of oil tea intake combined dietary patterns and T2D risk in middle-aged from Gongcheng area. Moreover, oil tea data were collected by trained researchers using a reliable questionnaire and real-time measurement. Finally, we have also controlled for several potential confounding factors for reliability in the logistic analyses. There're also several limitations. The cross-sectional nature of this study makes it possible to judge the causality between oil tea intake, dietary patterns and the risk of T2D in adults. In addition to the confounding factors that have been adjusted in the analysis model, there may be other unincluded factors that affect the results. Further longitudinal design studies are needed in the future to confirm these causal associations.

Conclusions

This is an observational study of oil tea and type 2 diabetes, and our results demonstrate that oil tea intake more than 3 times a day, and the daily intake with a certain amount (600~900mL/d), has an effect on reducing the risk of T2D in Gongcheng area. Further experiments and longitudinal studies are needed to unravel the causal association.

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AUTHOR DISCLOSURES

The authors declare no conflict of interest.

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