

Dietary cooking oils and cardiometabolic measurements in an elderly Chinese population

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ABSTRACT

OBJECTIVE To investigate three features of dietary cooking oil intake, namely, the consumption, cooking style, and composition of fatty acids in relation to several cardiometabolic measurements in an elderly Chinese population.

METHODS The elderly (≥ 65 years) participants for this study were recruited from two community health centers in the urban area of Shanghai. A questionnaire was administered to collect information on dietary oil consumption (low, medium and high) and cooking styles (fry or stir-fry vs. others) and the composition of fatty acids (poly-unsaturated vs. mono-unsaturated). The cardiometabolic measurements included anthropometry, blood pressure, fasting plasma glucose and serum lipids.

RESULTS The 1186 study participants had a mean age of 70.9 ± 5.4 years. The mean dietary oil consumption was 35.0 g/d, being low (< 25 g/d), medium (25–49 g/d) and high (≥ 50 g/d) in 485, 467 and 234 participants, respectively. The proportion of the fry or stir-fry cooking style and oils rich in mono-unsaturated fatty acids was 30.4% and 27.4%, respectively. Both before and after adjustment for sex, age, current smoking and alcohol intake, dietary oil consumption was significantly ($P \leq 0.02$) and positively associated with the prevalence of treated hypertension and fasting plasma glucose concentration. With similar adjustments as above and additional adjustment for dietary oil consumption, the fry or stir-fry cooking style was significantly ($P \leq 0.048$) and positively associated with body mass index, but inversely with systolic and diastolic blood pressure and serum low-density lipoprotein cholesterol, and the dietary intake of oils rich in mono-unsaturated fat acids was significantly ($P \leq 0.02$) and positively associated with diastolic blood pressure, serum triglycerides, total cholesterol and low-density lipoprotein cholesterol, and the prevalence of hypertriglyceridemia and hypercholesterolemia.

CONCLUSIONS This study showed that both the consumption and composition of fatty acids of the dietary oils mattered with regard to several cardiometabolic measurements in an elderly Chinese population.

Among various dietary factors, both the quality and quantity of fat intake play an important role in the development of cardiovascular disease. Indeed, each 1 tablespoon per day increment in the butter oil consumption was associated with a 7% higher risk of all-cause mortality, whereas each 1 tablespoon per day increment in the canola or olive oil consumption was associated with a 2%–3% lower risk of all-cause mortality.^[1] Dietary fat differs significantly in the composition of fatty acids, including saturated and unsaturated fatty acids. High dietary intake of fat rich in saturated fatty acids increases serum total cholesterol

(TC) and low-density lipoprotein cholesterol (LDL-C) and the risk of atherosclerotic disease.^[2] Unsaturated fatty acids can be further divided into mono-unsaturated fatty acids (MUFA) and poly-unsaturated fatty acids (PUFA), the dietary intake of which also differ in serum cholesterol concentration and the risk of atherosclerotic disease.^[3–7]

In China, cooking oil is a major dietary source of fat. According to a recent China survey in 2010 to 2012, the average daily dietary cooking oil intake per person was 41.8 g, which accounted for approximately 52.3% of the total fat intake. Of the 41.8 g cooking oil intake, 37.1 g was from ve-

getable oils, and 4.7 g from animal oils.^[8,9] The consumption significantly exceeded the 25–30 g of daily dietary oil intake recommended by the 2016 dietary guidelines for the Chinese residents.^[10] In China, the commonly used vegetable oils are from sunflower, corn, canola, peanut, seeds, rice, soybean, olive, sesame, cottonseeds and palm. Although these vegetable or plant oils are all rich in unsaturated fatty acids, they are still different in the composition of MUFA and PUFA. Some are rich in MUFA, such as olive oil and colseeds oil. But others are rich in PUFA, such as sunflower and corn oil. The rest combine MUFA with PUFA.^[2] In addition to the amount of dietary oil intake and the composition of fatty acids, another major feature of dietary oil intake is the cooking style. In the Chinese cuisine, a meal, especially lunch and supper, usually has several dishes. For the cooked warm dishes, scallion, ginger and garlic are usually fried with oil for a better taste of a dish.

Although dietary cooking oil has been studied previously, few studies investigated these three major features of dietary oil intake in relation to cardiometabolic measurements. In the present study, we investigated the dietary oil intake, the cooking style and the composition of PUFA and MUFA rich in cooking oils in relation to several cardiometabolic measurements including anthropometry, systolic blood pressure (SBP) and diastolic blood pressure (DBP), fasting plasma glucose and serum lipids in an elderly Chinese population.

METHODS

Study Population

The elderly (≥ 65 years) participants for this study were recruited from two community health centers located in the city center of Shanghai (Yuyuan and Sanlin). In addition to age, the only inclusion criterion was the completeness of recent blood chemistry measurements. Exclusion criteria included history of severe hepatic and renal diseases and inability to complete the questionnaire on the dietary oil intake. The study protocol was approved by the Ethics Committee of Ruijin Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai, China. All participants gave informed written consent.

Questionnaire Data

A trained investigator administered a dedicated dietary cooking oil questionnaire to collect information on ho-

usehold cooking frequency and style, household dietary oil consumption, category of household dietary oils and the number of meals at home.^[11] Dietary oil intake was estimated by cooking oil consumption, number of meals and number of times for cooking with oil. Cooking style included fry, stir-fry, braise, steam and stew. Dietary oil category included soybean, colseeds, palm, peanut, sunflowers, cottonseed, blend, animal, sesame, olive, rice, corn oils and so on.

We classified dietary oil intake as low (< 25 g/d), medium (25–49 g/d) and high (≥ 50 g/d) levels, respectively. We classified cooking style as fry and stir-fry, braise, steam and stew, and both. Saturated fatty acid oils including those rich in animal and palm oils were only used in a small number of study participants and therefore not included in the present analysis. MUFA oils included those from olive, colseeds, rice and peanut. PUFA oils included those from sesame, cottonseed, corn, soybean and sunflower.^[12] The same investigator also administered a standardized questionnaire to collect information on medical history, lifestyle and use of medications.

Blood Pressure and Anthropometric Measurements

Blood pressure (BP) was measured three times consecutively by an experienced physician using a validated Omron 7021 oscillometric monitor (Omron Healthcare, Kyoto, Japan), after the participants had rested for at least 5 min in the sitting position. These three BP readings were averaged for statistical analysis. Hypertension was defined as a BP of at least 140 mmHg for SBP or 90 mmHg for DBP or the use of antihypertensive drugs.

A trained technician performed anthropometric measurements, including body height, body weight, and waist and hip circumferences. Body mass index (BMI) was calculated as the body weight in kilograms divided by the body height in meters squared. Obesity was defined as a BMI ≥ 28 kg/m². Central obesity was defined as a waist circumference > 102 cm for men and > 88 cm for women.^[13]

Blood Biochemistry

Venous blood samples were drawn after overnight fasting for the measurement of fasting plasma glucose and serum triglycerides and TC, high-density lipoprotein cholesterol and LDL-C. Diabetes mellitus was defined as a fasting plasma glucose of at least 7.0 mmol/L, or a random plasma glucose of at least 11.1 mmol/L or the use of antidiabetic agents. Dyslipidemia was defined according to the 2023 Chinese guideline for the management of

dyslipidemia in adults: hypertriglyceridemia as a serum triglycerides concentration ≥ 2.30 mmol/L; hypercholesterolemia as a serum TC concentration ≥ 6.20 mmol/L or LDL-C ≥ 4.10 mmol/L; low high-density lipoprotein cholesterol as a level of 1.00 mmol/L or lower.^[14]

Statistical Analysis

The SAS software version 9.4 (SAS Institute, Cary, NC, USA) was used for data management and statistical analyses. All statistical tests were two-sided at the 0.05 significance level. Mean $\pm$ SD were computed for continuous variables with a normal distribution. Counts (percentages) were provided for categorical variables. Means and proportions were compared by the analysis of variance (ANOVA) and the chi-squared test, respectively. Tests for linear trend were performed by assigning median values to corresponding categories of oil intake and modeling the values as continuous variables. *P*-values for trend were assessed by the analysis of general linear model for continuous variables, and by the logistic regression for nominal categorical variables. The logistic regression analysis was performed for the associations of interest.

RESULTS

Characteristics of the Study Participants

Among the 1400 participants screened, the eligible 1311 participants started the questionnaire survey. There were 10 participants who reported a history of severe hepatic and renal diseases, 115 participants were unable to complete the questionnaire on the dietary oil intake, and 1186 participants were finally included the study. In addition, 6 participants did not have information about dietary oil category (Figure 1). The 1186 participants included 596 (50.3%) men and had a mean age of 70.9 ± 5.4 years and a mean BMI of 24.5 kg/m^2 . Men and women were significantly ($P \leq 0.02$) different in most of the demographic and clinical characteristics except for serum triglycerides concentration and the prevalence of general obesity, diabetes mellitus and hypertriglyceridemia ($P \geq 0.18$, Table 1).

The mean dietary oil intake was 35.0 g/d. The proportion of fry and stir-fry cooking was 30.4%. The proportion of MUFAs was 27.4%. Men and women were significantly different ($P = 0.02$) in the proportion of fry and stir-fry cooking (33.3% vs. 27.3%). They were not different ($P \geq$

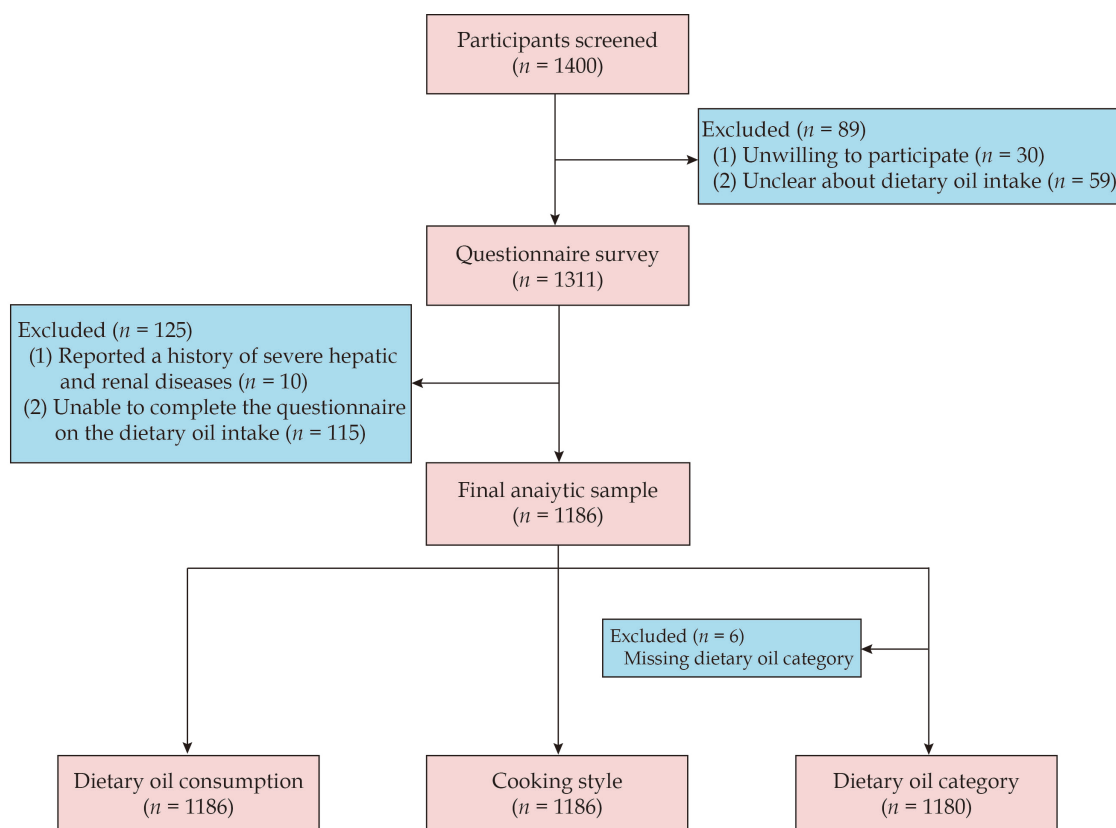


Figure 1 Flow chart of the study participants.



Table 1 Characteristics of the study participants.

Characteristics	Men (n = 596)	Women (n = 590)	P-value
Age, yrs	71.1 ± 5.3	70.7 ± 5.5	0.29
Body mass index, kg/m ²	24.7 ± 3.0	24.2 ± 3.4	0.02
General obesity	85 (14.3%)	71 (12.0%)	0.26
Waist circumference, cm	87.7 ± 13.8	81.7 ± 15.7	< 0.0001
Waist-to-hip ratio	0.91 ± 0.07	0.87 ± 0.06	< 0.0001
Central obesity	33 (5.5%)	164 (27.8%)	< 0.0001
Current smoking	182 (30.5%)	8 (1.4%)	< 0.0001
Alcohol intake	141 (23.7%)	15 (2.5%)	< 0.0001
Systolic blood pressure, mmHg	138.5 ± 17.4	135.4 ± 18.1	0.004
Diastolic blood pressure, mmHg	79.6 ± 10.6	75.9 ± 10.5	< 0.0001
Hypertension	341 (57.2%)	288 (48.8%)	0.004
Use of antihypertensive drugs	305 (51.2%)	252 (42.7%)	0.004
Blood biochemistry			
Fasting plasma glucose, mmol/L	6.26 ± 1.84	5.99 ± 1.49	0.02
Serum triglycerides, mmol/L	1.61 ± 1.00	1.66 ± 1.03	0.52
Serum total cholesterol, mmol/L	4.80 ± 1.03	5.31 ± 1.16	< 0.0001
Serum high-density lipoprotein cholesterol, mmol/L	1.38 ± 0.44	1.60 ± 0.41	< 0.0001
Serum low-density lipoprotein cholesterol, mmol/L	2.83 ± 0.85	3.06 ± 0.93	0.0001
Diabetes mellitus	121 (20.3%)	102 (17.3%)	0.18
Use of antidiabetic drugs	70 (11.7%)	59 (10.0%)	0.33
Hypertriglyceridemia	71 (11.9%)	58 (9.8%)	0.25
Use of fibrates	1 (0.2%)	0	0.32
Hypercholesterolemia	51 (8.6%)	94 (15.9%)	0.0001
Use of statins	28 (4.7%)	23 (3.9%)	0.50
Dietary oil intake, g/d	36.0 ± 27.2	33.9 ± 24.5	0.16
Fry or stir-fry oil cooking	199 (33.3%)	161 (27.3%)	0.02
Monounsaturated fat acids	54 (9.2%)	61 (10.3%)	0.45

Data are presented as means ± SD or n (%).

0.45) in the dietary oil intake in quantity (36.0 vs. 33.9 g/d) or the proportion of MUFAs (9.2% vs. 10.3%).

Dietary Oil Consumption

Table 2 shows the cardiometabolic measurements according to the low, medium and high dietary oil intake (40.9%, 39.4% and 19.7% of study participants, respectively). Dietary oil intake was significantly and positively associated with the use of antihypertensive drugs ($P = 0.004$), being 42.9%, 47.5% and 54.3%, respectively, in the low, medium and high dietary oil intake groups; it was also significantly and positively associated with fasting plasma glucose concentration ($P = 0.003$), being 5.92 mmol/L, 6.22 mmol/L and 6.33 mmol/L, respectively, in the low,

medium and high dietary oil intake groups. Statistical adjustments for sex, age, current smoking and alcohol intake did not materially change the results. Indeed, the adjusted odds ratio for the prevalence of treated hypertension increased from lower (< 25 g/d), to medium (25–49 g/d) and to higher (≥ 50 g/d) dietary oil intake ($P = 0.005$, Figure 2). The adjusted difference for fasting plasma glucose concentration was 0.41 mmol/L (95% CI: 0.11–0.71, $P = 0.007$) and 0.30 mmol/L (95% CI: 0.06–0.55, $P = 0.02$), respectively, for a higher (≥ 50 g/d) and medium (25–49 g/d) versus lower (< 25 g/d) dietary oil intake.

Dietary Oil Cooking Style

Table 3 shows the cardiometabolic measurements ac-



Table 2 Anthropometric measurements, blood pressure, fasting plasma glucose and serum lipids according to dietary oil intake.

Variable	Dietary oil intake, g/d			P_{trend} -value
	< 25 ($n = 485$)	25–49 ($n = 467$)	≥ 50 ($n = 234$)	
Body mass index, kg/m ²	24.3 $\pm$ 3.3	24.4 $\pm$ 3.1	24.8 $\pm$ 3.1	0.07
General obesity	64 (13.2%)	61 (13.1%)	31 (13.3%)	0.99
Waist circumference, cm	84.1 $\pm$ 15.9	84.9 $\pm$ 13.7	85.5 $\pm$ 15.9	0.22
Waist-to-hip ratio	0.89 $\pm$ 0.08	0.89 $\pm$ 0.06	0.90 $\pm$ 0.06	0.08
Central obesity	81 (16.7%)	72 (15.4%)	44 (18.8%)	0.63
Systolic blood pressure, mmHg	137.2 $\pm$ 18.4	136.6 $\pm$ 17.5	137.2 $\pm$ 17.0	0.88
Diastolic blood pressure, mmHg	78.0 $\pm$ 11.2	77.9 $\pm$ 10.2	77.0 $\pm$ 10.8	0.26
Use of antihypertensive drugs	208 (42.9%)	222 (47.5%)	127 (54.3%)	0.004
Fasting plasma glucose, mmol/L	5.92 $\pm$ 1.32	6.22 $\pm$ 1.89	6.33 $\pm$ 1.83	0.003
Use of antidiabetic drugs	45 (9.3%)	60 (12.9%)	24 (10.3%)	0.43
Serum triglycerides, mmol/L	1.64 $\pm$ 0.93	1.65 $\pm$ 1.12	1.59 $\pm$ 0.95	0.62
Serum total cholesterol, mmol/L	5.11 $\pm$ 1.13	5.02 $\pm$ 1.13	4.99 $\pm$ 1.08	0.22
Serum high-density lipoprotein cholesterol, mmol/L	1.51 $\pm$ 0.39	1.46 $\pm$ 0.39	1.49 $\pm$ 0.59	0.49
Serum low-density lipoprotein cholesterol, mmol/L	2.95 $\pm$ 0.91	2.94 $\pm$ 0.90	2.93 $\pm$ 0.87	0.76
Use of fibrates	0	1 (0.2%)	0	0.78
Use of statins	16 (3.3%)	21 (4.5%)	14 (6.0%)	0.09

Data are presented as means $\pm$ SD or n (%).

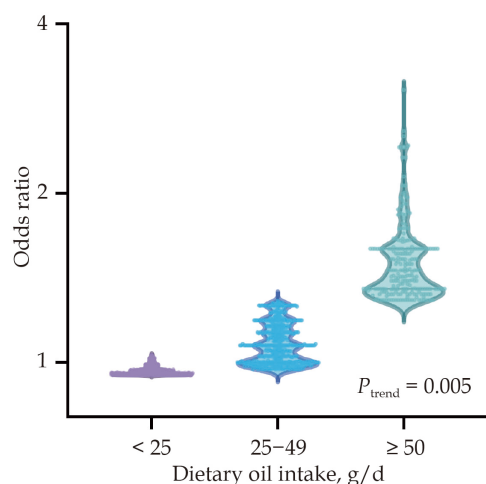


Figure 2 Adjusted odds ratios for the prevalence of treated hypertension in participants on higher (≥ 50 g/d), medium (25–49 g/d) and lower (< 25 g/d) dietary oil intake. The analysis was adjusted for sex, age, current smoking and alcohol intake.

cording to the braise, steam and stew, the mixed braise, steam and stew with fry and stir-fry and the fry or stir-fry cooking style (13.8%, 55.8% and 30.4% of study participants, respectively). Dietary oil intake was significantly ($P < 0.0001$) higher with the fry or stir-fry cooking style, being 26.3 g/d, 34.7 g/d and 39.5 g/d, respectively, in the groups of braise, steam and stew, the mixed braise, steam and stew with fry and stir-fry and the fry or stir-fry cooking st-

yle. The fry and stir-fry cooking style was significantly ($P \leq 0.04$) and positively associated with BMI (24.0 kg/m², 24.4 kg/m² and 24.8 kg/m², respectively), and inversely associated with SBP (138.5 mmHg, 137.8 mmHg and 134.7 mmHg, respectively) and DBP (77.4 mmHg, 78.7 mmHg and 76.2 mmHg, respectively) and serum LDL-C (2.97 mmol/L, 3.00 mmol/L and 2.81 mmol/L, respectively). After adjustment for sex, age, current smoking and alcohol intake, and dietary oil consumption, the results remained unchanged.

Dietary Oil Category

Table 4 shows the cardiometabolic measurements across the dietary oils rich in PUFAs, mixed PUFAs with MUFAs and MUFAs (38.1%, 34.5% and 27.4% of study participants, respectively). Dietary oil intake was higher with oils rich in PUFAs ($P = 0.02$), being 36.9 g/d, 35.4 g/d and 31.6 g/d, respectively, in oils rich in PUFAs, mixed PUFAs with MUFAs and MUFAs. In spite of lower dietary oil intake in quantity, dietary intake of oils rich in MUFAs was significantly ($P \leq 0.03$) and positively associated with DBP, and serum triglycerides, TC and LDL-C. After adjustment for sex, age, current smoking and alcohol intake, and for the dietary oil consumption, the results remained unaltered.

In categorical analyses with similar adjustments as ab-



Table 3 Anthropometric measurements, blood pressure, plasma glucose and serum lipids according to cooking style.

Variable	Cooking style			P_{trend} -value
	Braise, steam or stew ($n = 164$)	Mixed braise, steam or stew with fry or stir-fry ($n = 662$)	Fry or stir-fry ($n = 360$)	
Dietary oil intake, g/d	26.3 $\pm$ 21.2	34.7 $\pm$ 26.0	39.5 $\pm$ 27.4	< 0.0001
Body mass index, kg/m ²	24.0 $\pm$ 2.9	24.4 $\pm$ 3.2	24.8 $\pm$ 3.3	0.01
General obesity	15 (9.2%)	87 (13.1%)	54 (15.0%)	0.08
Waist circumference, cm	82.8 $\pm$ 17.4	84.7 $\pm$ 15.5	85.5 $\pm$ 12.9	0.08
Waist-to-hip ratio	0.88 $\pm$ 0.06	0.89 $\pm$ 0.08	0.89 $\pm$ 0.06	0.23
Central obesity	30 (18.3%)	112 (16.9%)	55 (15.3%)	0.36
Systolic blood pressure, mmHg	138.5 $\pm$ 18.5	137.8 $\pm$ 18.0	134.7 $\pm$ 16.9	0.008
Diastolic blood pressure, mmHg	77.4 $\pm$ 11.0	78.7 $\pm$ 10.9	76.2 $\pm$ 10.1	0.04
Use of antihypertensive drugs	81 (49.4%)	291 (44.0%)	185 (51.4%)	0.28
Fasting plasma glucose, mmol/L	5.93 $\pm$ 1.22	6.12 $\pm$ 1.55	6.25 $\pm$ 2.08	0.09
Use of antidiabetic drugs	24 (14.6%)	64 (9.7%)	41 (11.4%)	0.53
Serum triglycerides, mmol/L	1.70 $\pm$ 1.03	1.62 $\pm$ 1.06	1.63 $\pm$ 0.91	0.61
Serum total cholesterol, mmol/L	5.01 $\pm$ 1.06	5.13 $\pm$ 1.16	4.89 $\pm$ 1.05	0.08
Serum high-density lipoprotein cholesterol, mmol/L	1.41 $\pm$ 0.35	1.53 $\pm$ 0.42	1.43 $\pm$ 0.50	0.51
Serum low-density lipoprotein cholesterol, mmol/L	2.97 $\pm$ 0.89	3.00 $\pm$ 0.91	2.81 $\pm$ 0.87	0.02
Use of fibrates	0	1 (0.2%)	0	0.80
Use of statins	12 (7.3%)	24 (3.6%)	15 (4.2%)	0.22

Data are presented as means $\pm$ SD or n (%).

ove, the association was not significant for the prevalence of treated hypertension ($P \geq 0.48$), but it was statistically significant ($P \leq 0.02$) for the prevalence of hypertriglyceridemia and hypercholesterolemia when the MUFAs and PUFAs groups were contrasted (odds ratio = 1.74, 95% CI: 1.08–2.79 and odds ratio = 1.92, 95% CI: 1.24–3.00, respectively) (Figure 3).

DISCUSSION

Our key finding in an elderly Chinese population is that at the three features of the dietary cooking oil intake are associated with some of the cardiometabolic measurements such as treated hypertension, fasting plasma glucose concentration, BMI, hypertriglyceridemia and hypercholesterolemia. An immediate implication of our study is that dietary cooking oil intake indeed needs to be reduced in quantity and optimized in the cooking style and the choice of oils according to the composition of PUFAs and MUFAs.

A unique feature of our study is that we studied three major features of dietary cooking oil intake. Nonetheless, several previous studies have investigated one or another feature of dietary cooking oil intake. In a study on the chan-

ge in fat intake in the Chinese in the past three decades and its health consequences, the investigators observed a remarkably robust linear correlation ($r = 0.9900$ and $r = 0.9899$) between the consumption of dietary fat (mainly from vegetable oils) and the incidence and mortality of cardiovascular diseases.^[15] In a prospective epidemiologic study involving 125,287 participants from 18 countries in Africa, Asia, Europe, and North and South America, the investigators observed that total fat intake was associated with a higher SBP.^[16]

Our observation on the inverse association between SBP and DBP and the fry and stir-fry cooking style is in contrast to the results of several previous studies.^[17–19] The fry and stir-fry cooking style was indeed associated with a higher dietary oil consumption and a greater BMI. The observed lower BP and serum LDL-C concentration might be a consequence of selective survival in our elderly study population. In a large-scale (number of accesses: 212,341,708) China nationwide internet data-based survey, dietary fried food preferences were significantly and positively associated with the prevalence of hypertension ($r = 0.715$, $P < 0.001$).^[17] In the Fifth Korean National Health and Nutrition Examination Survey between 2010 and 2011, women who reported eating fried food more than twice a week, compared with those who rarely ate fried

Table 4 Anthropometric measurements, blood pressure, plasma glucose and serum lipids according to dietary oil category.

Variable	Category of dietary oil			P_{trend} value
	Polyunsaturated fatty acids (n = 450)	Mixed polyunsaturated and monounsaturated fatty acids (n = 407)	Monounsaturated fatty acids (n = 323)	
Dietary oil intake, g/d	36.9 ± 25.5	35.4 ± 25.3	31.6 ± 27.0	0.01
Body mass index, kg/m ²	24.3 ± 3.2	24.8 ± 3.3	24.1 ± 3.2	0.56
General obesity	61 (13.6%)	59 (14.5%)	35 (10.8%)	0.33
Waist circumference, cm	83.8 ± 15.7	85.1 ± 14.8	85.2 ± 14.5	0.18
Waist-to-hip ratio	0.89 ± 0.06	0.89 ± 0.08	0.89 ± 0.07	0.71
Central obesity	77 (17.1%)	61 (15.0%)	57 (17.7%)	0.92
Systolic blood pressure, mmHg	136.5 ± 18.0	137.4 ± 17.4	136.9 ± 18.1	0.73
Diastolic blood pressure, mmHg	75.9 ± 10.2	79.2 ± 10.8	78.6 ± 11.0	0.0002
Use of antihypertensive drugs	216 (48.0%)	194 (47.7%)	144 (44.6%)	0.37
Fasting plasma glucose, mmol/L	6.08 ± 1.61	6.16 ± 1.72	6.16 ± 1.76	0.57
Use of antidiabetic drugs	54 (12.0%)	43 (10.6%)	32 (9.9%)	0.35
Serum triglycerides, mmol/L	1.54 ± 0.79	1.66 ± 1.07	1.74 ± 1.20	0.02
Serum total cholesterol, mmol/L	4.92 ± 1.07	5.08 ± 1.13	5.16 ± 1.16	0.008
Serum high-density lipoprotein cholesterol, mmol/L	1.47 ± 0.38	1.50 ± 0.51	1.49 ± 0.42	0.51
Serum low-density lipoprotein cholesterol, mmol/L	2.85 ± 0.88	3.00 ± 0.88	3.00 ± 0.94	0.03
Use of fibrates	0	1 (0.3%)	0	0.89
Use of statins	18 (4.0%)	18 (4.4%)	15 (4.6%)	0.66

Data are presented as means ± SD or n (%).

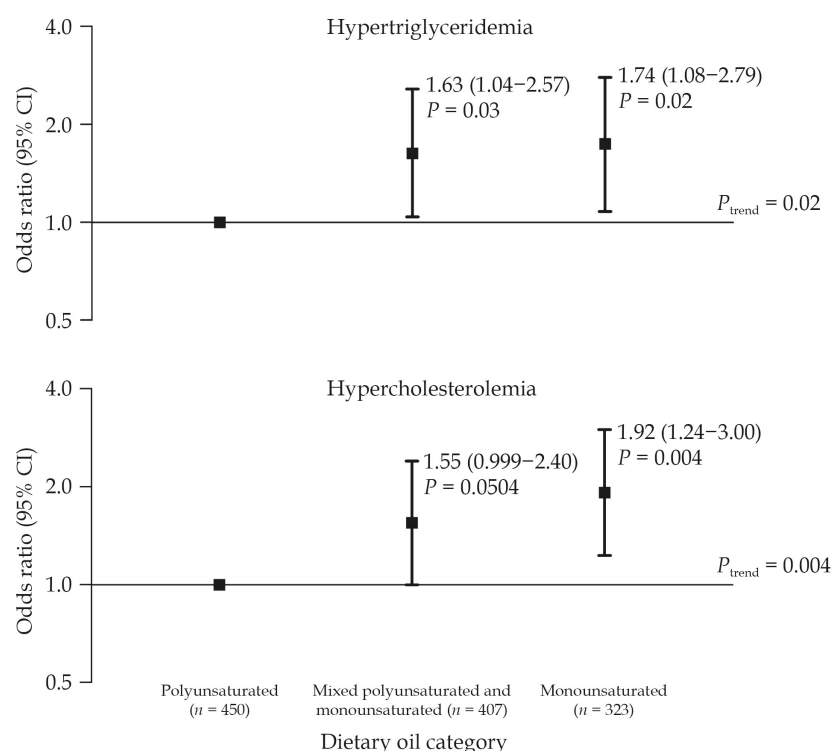


Figure 3 Adjusted odds ratios (95% CI) for the prevalence of hypertriglyceridemia and hypercholesterolemia in participants on monounsaturated and mixed polyunsaturated and monounsaturated versus polyunsaturated fatty acids. The analyses were adjusted for sex, age, current smoking, alcohol intake and dietary oil intake.



food, had a higher risk of hypertension (odds ratio = 2.20, 95% CI: 1.21–4.00, $P_{\text{trend}} = 0.0403$).^[18] Higher consumption of fried foods was also found to be significantly associated with a higher risk of hypertension in other ethnicities.^[19] The abovementioned internet survey showed similar positive association between the fry and stir-fry cooking style and BMI ($r = 0.667$, $P < 0.001$) as observed in our present study. Nonetheless, the observed inverse correlation between fry or stir-fry cooking style and BP or serum LDL-C concentration could still have possible explanations. Socio-economics, for instance, income, may be a factor. Several previous studies showed that income was positively associated with fried food consumption.^[20,21] Meanwhile, high income may help improve the accessibility to health care and eventually health status.^[22] Thus, high income may link lower BP and serum lipids with higher consumption of dietary oil and fried food.

Our observation on the association between MUFAs and hypertriglyceridemia is in line with the results of a recent randomized controlled trial on sesame and sunflower oils rich in PUFAs in 530 hypertensive patients who took the calcium channel blockers nifedipine treatment. Sesame (149.0 mg/dL) and sunflower oils (164.7 mg/dL), compared with the control group on nifedipine treatment only (188.6 mg/dL), decreased serum triglycerides significantly ($P < 0.05$).^[7]

Several possible mechanisms might explain the associations between the dietary cooking oil intake features and the cardiometabolic measurements. An interesting explanation is that excessive dietary fat intake may disrupt the gut microbiota, thereby affecting BP and other cardiometabolic measurements.^[23] In a study in mice on a low-fat diet, high-saturated fat diet exhibited reduced gut microbiota diversity and richness, along with an increased ratio of Firmicutes to Bacteroidetes, which might contribute to health-related diseases.^[24] In a study in 415 human participants, enrichment of *Klebsiella pneumoniae* was associated with BP elevation and the risk of hypertension.^[25]

LIMITATIONS

Our study has to be interpreted with the context of its limitations. Firstly, the study was cross-sectional and hence a causal inference cannot be drawn. Secondly, physical activity was not included in the questionnaire, which might be a confounding factor for the cardiometabolic measurements. Last but not least, our study was conducted in an elderly population. Whether the results of our study can be extrapolated to populations of wider age

range remains under investigation.

CONCLUSIONS

Our study in an elderly Chinese population showed that the dietary cooking oil intake features, such as the consumption, the fry or stir-fry cooking style, and MUFAs, were associated with some of the cardiometabolic measurements. Future studies should address whether this relationship is causal and reversible with regard to cardiovascular prevention and health.

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